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THE JOURNAL

OF THE

Canadian Mining Institute

1904

Containing the Papers and Proceedings of the Meetings of the Institute.

EDITED BY THE SECRETARY

VOLUME VII.

"The Institute as a body shall not be responsible for the statements or opinions advanced in the papers which may be read, or in the discussions which may take place at its meetings."—*By-Laws, par. xxxii.*

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JOURNAL OF THE CANADIAN MINING INSTITUTE, PART OF VOL. VII.

Proceedings of the 6th Annual General Meeting, held in Toronto, Ontario, on the 2nd, 3rd and 4th of March, 1904.

The 6th annual general meeting of the Canadian Mining Institute was held in the banquet hall of the King Edward Hotel, Toronto, on Wednesday, Thursday and Friday, the 2nd, 3rd and 4th of March, 1904.

The following members and guests signed the register of attendance:—

Eugene Coste, Toronto.
W. G. Miller, Toronto.
S. Dillon Mills, Toronto.
Elfric Drew Ingall, Ottawa.
R. W. Brock, Kingston.
Jno. McLeish, Ottawa.
Lewis L. Brophy, Ottawa.
Stevenson Brown, Montreal.
Thos. B. Caldwell, Lanark, Ont.
Frederick Hobart, New York.
J. Obalski, Inspector of Mines, Que.
Alfred E. Barlow, Ottawa.
James White, Ottawa.
B. A. C. Craig, Toronto.
J. M. Clark, Toronto.
J. A. Currie, Toronto.
Major W. Parson, Toronto.
John Piche, Copper Cliff, Ont.
C. H. Heys, Toronto.
Jas. H. Bowman, London, Ont.
C. Garratt, Sudbury, Ont.
A. McCharles, Sudbury, Ont.
Dr. Robert Bell, Ottawa.
Robert G. Leckie, Sudbury, Ont.
J. A. Dresser, Montreal.
J. E. Hardman, Montreal.
Hon. E. J. Davis, Toronto.
Dr. J. Bonsall Porter, Montreal.
Jos. Errington, Massey, Ont.
R. C. Barclay, Massey, Ont.
G. E. Silvester, Sudbury, Ont.
J. L. R. Parsons, Toronto.
E. B. Biggar, Toronto.
Thos. W. Gibson, Toronto.
A. P. Coleman, Toronto.
Wm. Thompson, Rossland, B.C.
Anthony Blum, Boston, Mass.
E. L. Fralick, Belleville, Ont.
M. J. Hendrick, Belleville, Ont.
O. N. Scott, Listowel, Ont.
P. Kirkgaard, Deloro, Ont.
S. F. Kirkpatrick, Kingston, Ont.
A. F. Rising, Madoc, Ont.
H. H. Moore, Toronto.
T. L. Walker, Toronto.
J. J. Bell, Toronto.
A. Ferland, Haileybury.
M. B. Baker, Kingston.
W. Nicol, Kingston.
Frank D. Adams, Montreal.
F. T. Snyder, Chicago.
C. C. Richards, Montreal.
T. D. Ledyard, Toronto.
H. C. Deyell, Montreal.
A. Longwell, Foxboro, Ont.
J. C. Gwillim, Kingston.

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John Hart, Hampstead.
B. C. Lott, Stirling, Ont.
John O. Cook, Marmora, Ont.

Students

R. Anson-Cartwright, Kingston.
Benj. Tett, Kingston.
P. McL. Forin, Kingston.
B. O. Strachan, Kingston.
E. T. Corkill, Kingston.
C. C. Williams, London, Ont.
F. N. Rutherford, South Monaghan, Ont.
C. L. Coulson, Welland.
E. R. Jackson, Seaforth.
Robt. H. Bryce, Toronto.
A. J. Elder, Barrie.
P. A. Laing, Dundas.
Wm. M. Edwards, Iroquois.
P. C. Coates, Toronto.
J. F. Hamilton, Toronto.
T. H. Plunkett, Toronto.
J. Parke, Toronto.
H. C. Chilver, Walkerville.
C. A. Chilver, Walkerville.
Chas. J. Ingles, Toronto.
M. T. Culbert, Toronto.
Henry Montgomery, Toronto.
J. Galbraith, Toronto.
J. C. MacMillan, Toronto.
J. H. Ryckman, Frontland.
W. A. Begg, Toronto.
C. W. Knight, Kingston.
L. E. Drummond, Kingston.
J. S. DeLury, Manilla, Ont.
R. E. Hore, Toronto.
G. C. Bateman, Kingston.
T. W. Cavers, Kingston.
K. A. Mackenzie, Toronto.
Geo. W. Bissett, Kincardine, Ont
L. B. Reynolds, Montreal.
E. J. Hassard, Toronto.
Ralph E. DeLury, Toronto.
Jas. C. Ross, Barrie.
A. T. Stuart, Hamilton.
H. A. C. Baker, Oshawa.

IST SESSION, WEDNESDAY MORNING.

The members assembled at half past ten on Wednesday morning, and the meeting was called to order by the President, Mr. Eugene Coste, E.M., who welcomed the members and guests.

The minutes of the last Annual General Meeting were read and approved.

The printed report of the Council for the past year having been distributed, the President said: Gentlemen, referring to the report of the Council in your hands, I may say that the preparation of this report was the last work done by the late Secretary. I received the report from him the morning he met with the sudden accident which unfortunately caused his death.

On the motion of Mr. J. Stevenson Brown, seconded by Prof. Miller, the report of the Council was adopted.

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REPORT OF COUNCIL, 1903.

The Council takes pleasure in submitting the following brief review of the work and status of the Institute during the year 1903:—

MEMBERSHIP.

The following statement shows the membership by provinces and countries as at 31st December, 1903, compared with the same period in each year since the organization of the Institute:—

—	1898	1899	1900	1901	1902	1903
Nova Scotia	16	16	19	27	31	30
New Brunswick	2	1	2	2	1	1
Quebec	66	77	77	77	79	69
Ontario	44	68	91	83	107	108
British Columbia	42	65	72	67	72	68
Manitoba	..	..	..	..	2	2
Newfoundland	..	1	2	2	2	2
Alberta	5	5	5	6	6	7
Yukon	..	..	..	2	5	11
Great Britain	4	9	7	12	14	12
United States	11	17	26	30	36	36
China	..	1	1	1	..	..
Hawaii Islands	..	1	..	..	1	1
Spain	..	1	2	2	1	1
Australia	..	..	..	..	1	1
Tasmania	..	..	..	..	..	1
South Africa	..	..	3	4	..	..
East Africa	..	..	..	1	1	1
Alaska	..	..	1	..	..	1
Mexico	..	..	1	1	1	3
Labrador	..	..	..	1	..	..
South America	..	..	..	1	1	2
Students	2	15	14	12	92	78
	192	277	323	331	453	435
Died during the year	2	4	4	4	2	3

The Council reports with profound sorrow the deaths of Mr. James Cooper, of Montreal, Col. King, Sherbrooke, and Mr. John McAree, D.L.S., of Toronto. Owing to the fluctuations of the

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mining business and removal from the country a number of resignations go into effect at this meeting, but it is confidently anticipated that the number of new members to be elected will more than compensate for these losses.

LIBRARY AND READING ROOM.

The premises occupied by the Institute in Room IV, Windsor Hotel, Montreal, having become too small for the proper accommodation and growing requirements of our library, the Council, at a special meeting called for the purpose, decided by a vote of 19 to 3 to remove the collection to Ottawa, where it now is under the personal supervision of the secretary.

The new premises in Orme's Hall, Wellington Street, Ottawa, are most conveniently located and are large enough for the purposes of the Institute for many years to come.

By this change a saving of $100 per annum is effected in rent.

Members may now obtain a loan of any work of reference in this collection for a limited period by giving a receipt and surety for the value of the book or books loaned. Already this system has been taken advantage of by a number of members. A new catalogue is being prepared for the printer and will be distributed among the members when completed.

MEETINGS.

The Annual meetings were held at Montreal on the 4th, 5th and 6th March, 1903, and were exceedingly well attended. The proposal to hold a joint meeting with the Lake Superior Mining Institute at Sault Ste. Marie, in September, was abandoned in consequence of the unsettled condition of the mining and metallurgical industries of that district. Several meetings of Council and special committees were held in Montreal and Toronto.

A meeting of the Eastern Ontario section was held in Kingston in November and a number of interesting subjects discussed.

PUBLICATIONS.

The papers read before the British Columbia meetings held at Nelson in September, 1902, and at the annual meetings in March last year, some thirty in all, constituting the contents of Volume VI of the Journal of the Institute, were, unfortunately, destroyed

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by fire in June on the eve of the completion of the volume. Owing to delay in the re-equipment of the contractors' printing plant and the Secretary's absence, first in the Yukon and later in Great Britain, the work of re-setting the lost volume was not begun until his return early in December, but, by dint of hard work, it has been completed and will be in the hands of the members on or about the date of our annual meetings. In order to meet the increased demand for our publications a larger edition has been struck off.

Several hundred copies of each of the papers by Messrs. MacDonald, Miller, Hille, Coste and Robinson were printed in pamphlet form and distributed during the year.

A revised List of Members containing the Charter and By-Laws of the Institute was also printed and distributed among the members.

At the close of the year the Secretary compiled and printed in pamphlet form a very complete and handily arranged volume of Indices to the authors and papers read before the Institute and its antecedent organizations from 1891 to the end of 1903. This useful little volume, which has also been incorporated in the Journal for 1903, is now tabled for your inspection.

PROPOSED CHEMICAL AND METALLURGICAL SECTION.

Arising out of the admirable suggestions contained in the paper presented by Mr. W. Dixon Craig at our last annual meeting circulars have been issued, not only to our own members, but to many other Canadian chemists and metallurgists, with the object of bringing to a focus the question of organizing a Chemical and Metallurgical Section. Such an organization can accomplish much, not only for Canadian chemistry and metallurgy, but for mining and its associated industries. A meeting for the purpose of promoting this organization will be held on Thursday afternoon, 3rd March.

STUDENTS' COMPETITION.

Nine papers were submitted by Student Members. The Committee of Award in the Geological Section (Messrs. Goodwin,

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Adams and Walker), recommended that the cash prize of twenty-five dollars be given to Mr. S. H. Boright for his paper "On the Geology of the Northern Portion of the Boisdale Hills Anticline." In the Mining Division the Committee (Messrs. Hardman and Coste), recommended that Mr. Norman W. Parlee be given a similar cash prize for his paper on "Rock Drilling and Blasting." None of the papers being deemed to have sufficient merit to warrant its award, the President's gold medal was not given.

MINING STATISTICS.

The importance and necessity for greater uniformity in the compilation and publication of official mining statistics by the Provincial and Dominion Governments, was prominently discussed at our last annual meeting and the question referred to a committee, which has held several meetings. Their report will be submitted for your consideration.

FINANCES.

The audited Statement of the Treasurer, which will be submitted to you in detail at the annual meeting, shows a cash balance on hand of $2,912.73. This unusually large balance is, of course, largely due to the fact that the publication of Volume VI was, owing to the fire, not issued during the year. The following statements shows the receipts and disbursements from the organization of the Institute to the end of our last financial year, *i.e.*, 31st January, 1904:—

	Receipts.	Disbursements.
1898	$2,674 67	$2,454 85
1899	3,421 10	3,156 05
1900	3,601 50	3,455 76
1901	4,076 50	3,749 71
1902	6,330 89	5,655 80
1903	6,061 30	4,831 06

Submitted on behalf of the Council.

EUGENE COSTE, *President.*

B. T. A. BELL, *Secretary.*

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TREASURER'S REPORT.

Mr. J. Stevenson Brown, Treasurer, presented the financial statement for the year, duly audited and approved by the Council, which was as follows:

TREASURER'S STATEMENT.

YEAR ENDING FEBRUARY 1ST, 1904.

RECEIPTS.

Balance from last year		$1,682 49
Subscriptions, 284, at $10.00	$2,840 00	
Student Members, 9, at $2.00	18 00	
University members, 76, at $1.00	76 00	
Arrears collected	210 00	
Sale of Journals	40 25	
Dominion Government Grant	3,000 00	
Interest	13 05	
		6,197 30
Total receipts		$7,879 79
LESS		
Disbursements per statement		4,831 06
Balance on hand		$3,048 73

SUMMARY STATEMENT

SHOWING DISTRIBUTIONS OF DISBURSEMENTS TO THE VARIOUS WORK AND BUSINESS OF THE INSTITUTE.

Publications:		
Cuts, line drawings, half-tones, etc.	$ 387 99	
Copying, proof reading and charges re Vol. VI	1,300 00	
Printing, etc.	153 19	
Postage, express and other charges	122 26	
		$1,963 44
Library:		
Rent	$ 271 66	
Care of Library	40 00	
New Books	76 00	
Binding	32 00	
Furniture and signs	187 25	
Removing to Ottawa	62 37	
Insurance	17 00	
		686 28
Meetings:		
Reporting Annual Meeting	$ 100 00	
Typewriting, copying, annual dinner and sundry disbursements	278 90	
Council meetings	135 00	
Deputations	255 10	
Advertising	50 00	
		819 00

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Secretary's Office:		
Annual grant	$ 500 00	
Postage and telegrams	61 12	
Stationery and typewriting supplies	77 38	
		638 50
Treasurer's Office:		
Annual grant	$ 500 00	
Bank charges on cheques and drafts	62 35	
Postage and telegrams	40 00	
Stationery and sundries	36 49	
Audit	10 00	
		648 84
Prizes, Students' Competitions:		
L. P. Silver, $25.00; H. P. Depensier, $25.00; N. E. Parlee, $25.00		75 00
		$4,831 06

MR. J. STEVENSON BROWN said—I may point out that this statement shows that $136.00 were received more than is stated in the summary statement mentioned in the report of the Council. That is due to the fact that between the 1st of February and the present date a few members have paid their subscriptions. I would also like to point out that the balance appearing in the statement, amounting to over $3,000.00, is larger than it should be if all ordinary accounts were in and paid. Owing to the unfortunate fire which took place at Ottawa, Vol. VI. of the Journal of the Institute, which was about ready to be issued, was destroyed. It will entail extra expense to have the volume re-issued. There are about $800.00 involved in that, and the payment of that amount will only be made this year, so that the balance really should be only about $2,200.00. I would also like to explain that in former years the secretary was given an allowance, which was intended purely for the ordinary running expenses of the office, and it was customary for him to employ extra help, as he required it, in connections with the pressing work of the Institute, and particularly the issuing of the Volumes of our Journal. The expenses in connection with this extra help were always paid directly by the Institute. Last year, however, the Council gave the secretary a fixed sum of $1,500.00, to cover not only all ordinary expenses of the office, but also the extra help required as above stated. Of this amount, in my statement showing the distribution of the disbursements, $500.00 are charged to the secretary's office,

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and $1,000.00 are put down to the cost of publication. I wish to add another word with reference to this financial report: Though no special allowance has been made by the Council to the secretary for the payment of the extra help which has been needed in regard to the re-publication of Vol. VI. after the fire, the sum of $250.00 is, however, placed in this account to cover that, and I paid it on a telegram from, and under the instructions of, the president, and I would like to have this action confirmed at this meeting.

On motion of Mr. Craig, duly seconded, the meeting approved of the appropriation of $250.00 just mentioned by the Treasurer, for the re-publication of Vol. VI.

On the motion of Mr. Obalski, seconded by Mr. Mills, the report of the Treasurer was adopted.

NEW MEMBERS.

The following new members were elected:

A. Harry Hook, Chemist, 9 Suffolk Place, Toronto, Ont.
H. B. Wright, Chief Engineer Crow's Nest Pass Coal Co., Fernie, B.C.
Henry L. Manley, Mining Engineer, Crow's Nest Pass Coal Co., Fernie, B.C.
Milton T. Culbert, Geologist, 226 McCaul St., Toronto, Ont.
Herbert C. Philpott, 320 Brunswick Ave., Toronto, Ont.
S. L. Spafford, Capelton, Que.
Robert McKay, Barrister, Messrs. McKay, Dods & Grant, Toronto.
H. S. Burrell, Belleville, Ont.
J. L. R. Parsons, Geologist, 12 Lowther Ave., Toronto, Ont.
Anthony Blum, Mine Owner and Operator, 35 Court St., Boston, Mass.
Elfric Drew Ingall, Mining Engineer, Geological Survey, Ottawa, Ont.
A. P. Coleman, Professor of Geology, School of Practical Science, Toronto, Ont.
J. W. Tyrrell, Civil and Mining Engineer, Hamilton, Ont.
Chas. H. Heys, Consulting Chemist, 114 Bay St., Toronto, Ont.
Chas. B. Jackes, Barrister, Toronto, Ont.
Henry Montgomery, M.A., Ph.D., Trinity College, Toronto, Ont.
A. Ferland, Mine Owner, Haileybury, Ont.

The members of the Engineering Society of the School of Practical Science, Toronto, having applied to become affiliated

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with the Institute in a body, under paragraph 10 of the by-laws, were duly elected as university members, as per the following list:

C. S. Acton, Toronto.
E. W. Banting, Toronto.
M. Bates, Chatham, Ont.
G. W. Bissett, Toronto.
G. Galt, Rossland, B.C.
E. J. Hassard, Mono Mills, Ont.
W. Huber, Bracebridge, Ont.
H. A. Johnson, Hamilton.
K. A. MacKenzie, Toronto.
J. G. McMillan, Toronto.
C. J. Murphy, St. Catharines.
R. C. Purser, Windsor.
C. Rolfson, Walkerville.
J. H. Ryckman, Hamilton.
W. A. Begg, West Flamboro.
W. C. Campbell, Keene.
E. F. Pullen, Oakville.
C. A. Chilver, Walkerville.
G. P. Stirrett, Petrolia.
P. C. Coates, Victoria, B.C.
A. J. Elder, Barrie, Ont.
J. C. Fleck, Ottawa.
C. J. Ingles, Toronto.
E. R. Jackson, Seaforth, Ont.
P. A. Laing, Dundas, Ont.
J. Parke, Oil City.
F. N. Rutherford, South Monaghan.
R. A. Bryce, Toronto.
C. L. Coulson, Welland.
W. M. Edwards, Iroquois.
J. F. Hamilton, Dunedin.
T. H. Plunkett, Meaford.
S. M. Hill, St. Thomas.
C. G. Williams, London, Ont.
D. W. McKenzie, Lockalsh.
H. P. Thomson, Toronto.
H. L. Chilver, Walkerville.
F. C. Broadfoot, Seaforth.

SCRUTINEERS APPOINTED.

On motion duly made and seconded, Messrs. J. Obalski, Frederick Hobart and S. Dillon Mills were appointed scrutineers of the annual vote for the election of officers, which, it was announced by the President, would take place on the Friday afternoon session.

AUDITORS RE-ELECTED.

On motion, duly made and seconded, Messrs. H. W. DeCourtenay and Geo. McDougall were re-elected auditors.

ANNOUNCEMENT BY TREASURER.

MR. J. STEVENSON BROWN said—I wish to explain that in regard to the lamented death which took place yesterday of our late Secretary, we have this morning telegraphed to Ottawa ordering a wreath for his coffin. The wreath will bear the initials of the Institute, "C.M.I., 1904," and the design will be the designs of the Institute, of the two hammers crossed at the centre, surmounted by the beaver. As to the appointment of a successor to

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the late Mr. Bell, I do not think it is a question that we can very well deal with here, and so I shall make a suggestion, which I hope will meet with the approval of this meeting. I have been in close touch with Mr. Bell for the last three or four years, and as there are probably few who know better the value of the services he rendered to the Institute, I wish to speak in the highest terms of praise of the faithful manner in which he performed his duties, and of the interest which he took in the welfare of the Institute. It is out of the question that we can appoint a successor at this meeting. The selection of a gentleman to take Mr. Bell's place requires careful consideration; I therefore beg to suggest that Mr. Coste, on whose judgment we can all rely, and Mr. Jno. E. Hardman, in whom the members of the Institute have much confidence, be appointed a committee to suggest to the Council a successor for our late Secretary.

The President suggested that Mr. Brown should also act on that committee.

Mr. Craig—It would appear to me that as Mr. Bell was re-nominated for Secretary, there will have to be an election to fill the vacancy.

The President—According to the by-laws, several weeks' notice must be given of the nomination of a gentleman to fill the office. That being the case we cannot, of course, elect a Secretary at this meeting. It seems to me that the best thing to do would be to vote on Mr. Bell's name this year, as it is printed on the ballot paper, and as most of the signed ballots are probably in the box by now, and to leave it to the Council to appoint an acting secretary *pro tem,* until a new Secretary can be elected at the next annual meeting.

Mr. Brown—I was under the impression that there was a clause in our by-laws providing that, in the event of the death or removal of one of our officers, the vacancy could be filled by the Council. That is done in a great many similar bodies, and although there is no provision for it in connection with our Institute, as the president has just suggested, the Council could name an Acting Secretary until such time as the Secretary can be elected at the next annual meeting. It is clear that we cannot elect a

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secretary, now, and the arrangement suggested by the President is apparently the only one that can be arrived at.

MR. CLARK, K.C.—The by-laws are very clear that the Secretary is to hold office until he is elected at the annual meeting. It is, I think, within the scope of this meeting, or of the Council, to appoint a person to act temporarily until the office is filled in the regular way.

On the motion of Mr. E. D. Ingall, duly seconded, it was decided that it should be left to the Council to select a Secretary to act for the time being.

The meeting adjourned at one o'clock.

2ND SESSION, WEDNESDAY AFTERNOON.

The members of the Institute met at half-past two o'clock, Mr. Coste, the President, in the chair.

The PRESIDENT—Before proceeding with the business of the meeting it is my very painful duty, and with feelings of great sadness, that I have to announce and to refer to the irreparable loss we have sustained in the death, which took place yesterday, of our Secretary. He was for so long a time the soul and life of our meetings, and the guiding spirit of our Institute ever since its foundation, and even long before, ever since in '91, when the General Mining Association of the Province of Quebec was formed, that it is hard indeed for us to realize that henceforth he will be with us no more. In the many years he has been identified with the mining interests of Canada he has rendered to them many valuable services, and for what he has thus accomplished his memory will live long among the mining men of Canada, but especially among the members of this Institute. My regret and sorrow are such that I cannot at present say more. It is indeed unnecessary, at a meeting of this Institute, to recount his many qualities of heart and brain, so well known to us all. Even those that he at times opposed strongly, in the interests of the mining men and of this Institute, were nevertheless at heart his friends.

The President then read a letter from Col. Anderson, President of the Canadian Society of Civil Engineers, expressing the sorrow of that Society on learning of Mr. Bell's death.

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MR. J. STEVENSON BROWN—I do not know that I can add anything to what Mr. Coste has already said as to the great loss which this Institute has sustained in the death of our late Secretary, Mr. Bell. He was beloved by us all for his sterling manly qualities. He always did what he believed to be best in the interest of this Institute, and although he was a hard fighter, he had the respect and esteem of those who were sometimes opposed to his views; these he expressed freely, in the meetings and out of the meetings. He always acted in a generous spirit of fair play, and his conduct was always calculated to advance the interests of this Institute, and the mining industry of Canada. I have been very closely connected with Mr. Bell during the last four years, in the office of Treasurer I have the honor to hold, and I can truly say that we will have to seek far and wide to find a man who will discharge the duties of the position of Secretary so well as he did. I shall not dwell on the subject, because my heart is too full of grief, but will move the following resolution:

Resolved—That the Canadian Mining Institute in annual convention assembled, records its profound regret and sorrow at the untimely death of its Secretary, Mr. B. T. A. Bell. In testifying to the great value of the work he has accomplished in the interest not only of this Institute but of the whole mining community, and to his untiring energy and zeal in furthering the objects of the Institute, whose welfare he had so much at heart; the officers and members desire to express to Mrs. Bell and family, their deep sympathy in their sad bereavement, and that a copy of this resolution be forwarded to Mrs. Bell.

PROF. MILLER—Our President and Mr. Brown have so well expressed the feelings of this Institute at the great loss we have sustained, that it is unnecessary for me to add anything further, and I beg to second this resolution.

MR. OBALSKI—As representing the mining community of the province of Quebec, I wish to bear testimony to the high character of our friend, the late Mr. Bell. I have been connected with Mr. Bell for many years, and I know the interest he took in the mining business of Canada and the valuable services which he rendered to that industry and to this Institute. I express the sorrow and

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deep regret of all the mining community of the province of Quebec.

The above resolution was unanimously adopted.

THE PRESIDENTIAL ADDRESS.

The President, Mr. Eugene Coste, then presented the annual presidential address. Mr. Coste in rising to address the meeting was greeted with warm applause.

This address is printed in full on page 26 of this volume.

On the motion of Prof. Miller, seconded by Mr. Obalski, the thanks of the Institute were accorded to the president for his able address.

NOTES ON MINING AND SMELTING IN THE BOUNDARY DISTRICT, B.C.

The paper by Mr. Frederick Keffer, M.E., of Greenwood, B.C., on the above subject was presented and read by Prof. Miller. It will be found on page 42 of this volume.

After the discussion* of the paper by Prof. Miller, Prof. Brock and the President, the thanks of the Institute were accorded to Mr. Keffer for his valuable paper.

ON THE ORE DEPOSITS OF ROSSLAND, B.C.

The paper by Mr. E. B. Kirby, E.M., of Rossland, B.C., on the above subject was presented and read by Prof. R. W. Brock; it will be found on page 47 of this volume.

After the discussion of the paper by the president, Prof. Brock, Prof. Coleman, Mr. Thompson, Dr. Barlow, Mr. E. D. Ingall and Prof. Mickle, the thanks of the Institute were accorded to Mr. Kirby for his interesting paper and his most valuable maps accompanying it.

At the request of the President Mr. Thompson, of Rossland, B.C., addressed the meeting on the concentration of the low-grade ores of the Rossland district; these remarks will be found in this volume following the above discussions of Mr. Kirby's paper.

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* The discussion of each paper will be found in this volume following the papers to which they refer.

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The following paper was read, in the absence of the author, by title, and is published in this volume on page 70: "On a Water Supply for Hawaiian Sugar Plantations," by Mr. J. N. S. Williams, of Puunene, Maui, Hawaiian Islands.

The meeting then adjourned.

3RD SESSION, WEDNESDAY EVENING.

The members re-assembled at eight o'clock, the President (Mr. Coste) in the chair.

NOTES ON THE CONSTRUCTION OF MINE BULK HEADS.

The paper by Mr. Thompson, of Rossland, B.C., on the above subject was read by himself. It will be found on page 82 of this volume.

After the conclusion of the paper Mr. Thompson made a few remarks, after which the thanks of the Institute were accorded him for his valuable paper.

Mr. Coste, the President, having left with Mr. Stevenson Brown, Treasurer, to proceed to Ottawa to attend the funeral of the late Secretary, Mr. Bell, the chair was taken by Professor Miller.

POPLAR CREEK AND OTHER NEW GOLD FIELDS OF THE LARDEAU DISTRICT.

The paper on the above subject, by Prof. R. W. Brock, was read by himself, and illustrated by lantern slides. The paper will be found on page 87 of this volume. After the discussion of the paper by Prof. Miller, Prof. Coleman, Mr. Ingall, Prof. Brock, Mr. Obalski and Prof. Mickle, the thanks of the Institute were accorded Prof. Brock for his valuable paper.

ON THE MINES OF ONTARIO.

The paper by Mr. W. E. H. Carter, M.E., of Toronto, on the above subject was presented and read by Dr. Barlow, and was illustrated by lantern slides of some of the mines of the province. The paper will be found on page 114 of this volume.

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THE STUDY OF STRATIGRAPHY.

Dr. W. A. Parks, Toronto, then discussed the above subject.

Dr. Parks stated that he had not sufficient time to prepare the paper, owing to a train of circumstances, but he briefly outlined an idea of what he intended to say. (This will be found on page 168 of this volume.) Prof. Parks stated that in the University of Toronto they were endeavoring to improve their palaeontological specimens, and they had a good many specimens from abroad, which they had been able to purchase, but unfortunately they could not purchase Canadian specimens of fossils. If any of the gentlemen present who came in contact with the stratified deposits of Ontario would send to the University any fossils they might obtain, the University would thoroughly appreciate it, and would be glad to pay any expenses in connection with the shipment of such.

After the discussion of the subject by Mr. Craig, Prof Miller, and Mr. Ingall, the thanks of the Institute were accorded to Dr. Parks for his interesting remarks.

SOME RECENT ROCK MOVEMENTS IN THE LAURENTIAN AND HURONIAN AREAS.

The paper by Mr. S. Dillon Mills, of Toronto, on the above subject, was read by himself. This paper will be found on page 177 of this volume.

Prof. Miller said that many of the papers presented to the Institute dealt with very important subjects, such as that just treated of by Mr. Mills. It was impossible to discuss them properly from merely hearing them read, and he thought that members should have an opportunity of considering them, and if they wished, of sending in their criticisms to the Secretary for publication in the Journal.

It being now after eleven o'clock, Prof. Miller, who was in the chair, announced that the students' session would commence at half-past nine to-morrow (Thursday) morning. He continued: Our late Secretary, who was a great friend of the students, frequently said that in the students' competition the Institute had received some of the very best papers that had ever been printed

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in its transactions. Some of the student members had given a great deal of time to this work, and he trusted there would be a good muster of the senior members of the Institute at the morning session.

The meeting then adjourned until Thursday morning.

4TH SESSION, THURSDAY MORNING (STUDENTS' SESSION).

The members of the Institute re-assembled on Thursday morning at half-past nine o'clock, Prof. Miller in the chair.

The CHAIRMAN said—I believe that one of the most important parts of the work of this Institute is the encouraging of students to present papers, and I am glad that there is such a large attendance this morning.

THE RELATIVE ATTRACTION OF SOME COMMON MINERALS FOR RESIDUUM OIL.

The paper by Mr. J. F. Hamilton, School of Practical Science, Toronto, on the above subject, was read by himself, while he illustrated on the blackboard the relative attraction of the different minerals for the oil. The paper will be found on page 185 of this volume.

After the discussion of this paper by Prof. Porter, Prof. Kirkpatrick, Mr. Hamilton, Mr. Mills, Prof. Mickle, Dr. Walker, and Dr. Adams, the thanks of the Institute were accorded Mr. Hamilton for his valuable paper and interesting illustrations.

RATE OF SOLUTION OF GOLD IN POTASSIUM CYANIDE.

The paper by Mr. T. H. Plunkett, School of Practical Science, Toronto, on the above subject was read by himself. This will be found on page 192 of this volume.

After the discussion of the paper by Mr. Thompson, Mr. Mills, Dr. Porter and Prof. Mickle, the thanks of the Institute were accorded Mr. Plunkett for his valuable paper.

TREATMENT OF THE DRY ORES OF THE SLOCAN.

The paper on the above subject, by Mr. T. W. Cavers, School of Mining, Kingston, Ont., was read by himself. This paper will be found on page 199 of this volume.

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After the discussion of the paper by Prof. Mickle, Prof. Kirkpatrick, Dr. Porter, Mr. Cavers and Prof. Gwillim, the thanks of the Institute were accorded Mr. Cavers for his valuable paper.

NOTES ON SOME DEPOSITS IN THE EASTERN ONTARIO GOLD BELT OF CANADA.

The paper on the above subject by Mr. C. W. Knight, School of Mining, Kingston, was read by himself. This paper will be found on page 210 of this volume.

After the discussion of the paper by Prof. Miller, Mr. M. B. Baker, Mr. Mills, Prof. Mickle and Mr. Fralick, the thanks of the Institute were accorded Mr. Knight for his valuable paper.

Through respect to the memory of the deceased Secretary of the Institute, the Thursday afternoon session of the Institute was suspended, by decision of the Council, during the funeral that afternoon at Ottawa.

5TH SESSION, THURSDAY EVENING.

The members of the Institute re-assembled Thursday evening at 8 o'clock, Prof. Miller in the chair.

The CHAIRMAN—As we all know radium is attracting a great deal of attention at present, it is very interesting to find that the province of Quebec has very promising supplies of this element. Mr. Obalski will enlighten us on the subject tonight.

ON MINERALS CONTAINING RADIUM IN QUEBEC.

The paper on the above subject by Mr. J. Obalski, Inspector of Mines of the province of Quebec, was read by himself. This paper will be found on page 245 of this volume.

After the discussion of the paper by Prof. Miller, Mr. Obalski, Dr. McLennan, Prof. Mickle, Mr. Mills and Mr. Fralick, the thanks of the Institute were accorded Mr. Obalski for his valuable paper and the interesting radiographs which had been taken with one of the two specimens he presented.

The chairman also expressed the thanks of the Institute to

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Dr. McLennan for his interesting remarks on this new and attractive subject.

ON THE EXPLORATION OF ONTARIO IRON RANGES.

The paper on the above subject by Mr. A. B. Willmott, of Sault Ste. Marie, was read by Dr. Coleman. This paper will be found on page 257 of this volume.

After the discussion of the paper by Prof. Miller, Prof. Coleman and Dr. Barlow, the thanks of the Institute were accorded Mr. Willmott for his able paper, and to Dr. Coleman for the reading of it.

The chairman then introduced the Hon. E. J. Davis, Commissioner of Crown Lands, whose address will be found on page 267 of this volume.

ON MAGNETIC SEPARATION.

The paper on the above subject, by Mr. F. T. Snyder, of Chicago, was read by himself. This paper will be found on page 270 of this volume.

After the discussion of the paper by Prof. Miller, Mr. B. A. C. Craig, Mr. Obalski, Dr. Porter, Dr. Barlow, Mr. T. W. Gibson, Mr. M. B. Baker and Mr. Snyder, the thanks of the Institute were accorded Mr. Snyder for his valuable paper.

The meeting then adjourned.

6TH SESSION, FRIDAY MORNING (STUDENTS' SESSION).

The members of the Institute re-assembled on Friday morning at 10.30 o'clock, Prof. Miller in the chair.

NOTES ON THE OCCURRENCES, PRODUCTION AND USES OF MICA.

The paper on the above subject, by Mr. E. T. Corkill, Queen's University, Kingston, was read by himself. This paper will be found on page 284 of this volume.

After the discussion of this paper by Mr. Obalski, Prof. Miller, Mr. Fralick, Mr. Morrison and Dr. Adams, the thanks of the Institute were accorded Mr. Corkill for his valuable paper.

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THE CLORINATION PROCESS, AT NORTH BROOKFIELD, N.S.

The paper on the above subject by Mr. H. Forbes, McGill University, Montreal, was read by Dr. Porter. This paper will be found on page 308 of this volume.

After the discussion of this paper by Dr. Porter, Prof. Mickle, and Mr. Morrison, the thanks of the Institute were accorded Mr. Forbes for his valuable paper, and also to Dr. Porter for reading it.

A FEW FEATURES OF MINING IN THE REGENT GROUP OF MINES, NEGAUNEE, MICH.

The paper on the above subject by Mr. M. B. Atkinson, McGill University, Montreal, was read by Mr. Deyell. This paper will be found on page 319 of this volume.

After the discussion of the paper by Prof. Mickle and Mr. Deyell the thanks of the Institute were accorded Mr. Atkinson for his valuable paper, and to Mr. Deyell for reading it.

THE PIONEER IRON MINE, ELY, MINN.

The paper on the above subject by Mr. E. J. Carlyle, McGill University, was read by Dr. Porter, and will be found on page 335 of this volume.

After the discussion of the paper by Major Leckie and Dr. Porter, the thanks of the Institute were accorded Mr. Carlyle for his valuable paper, and to Dr. Porter for reading it.

7TH SESSION, FRIDAY AFTERNOON.

The President, Mr. Eugene Coste, having returned from Ottawa, occupied the chair.

Before the proceedings opened MR. COSTE said—I attended the funeral of our late Secretary, Mr. Bell, at Ottawa yesterday, and in company with Mr. Stevenson Brown, Major Leckie and Mr. Hardman, represented the Institute. There was a large wreath from the Institute on the coffin, with the crossed hammers, the beaver and the motto of the Institute. I may say that there was a very large attendance at the funeral, and that an impressive service was conducted by the Rev. Dr. Barclay, of Montreal. The

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Quebec Mining Association was represented by Mr. A. W. Stevenson, of Montreal, who is also one of our members. The last thoughts of our late Secretary were all about the Institute, and for the success of this meeting, and immediately after I left him, last Saturday afternoon, he went to sleep, and afterwards became and remained unconscious practically all the time until his death on Tuesday morning, and the conversation he had with me last Saturday about the Institute was his last conversation.

NOTES ON THE BRITISH COLUMBIA ZINC PROBLEM.

The paper on the above subject by Mr. A. C. Garde, M.E., of Sandon, B.C., was read by Prof. Gwillim. This paper will be found on page 368 of this volume.

After the discussion of the paper by the President, Prof. Gwillim, Prof. Miller and Mr. Snyder, the thanks of the Institute were accorded to Mr. Garde for his valuable paper, and to Prof. Gwillim for reading it.

THE UNDEVELOPED MINERAL RESOURCES OF ONTARIO.

The paper on the above subject by Prof. Miller, Toronto, was read by himself. This will be found on page 377 of this volume.

After the discussion of the paper by the President, Mr. Gibson, Dr. Bell, Prof. Montgomery, Dr. Adams and Dr. Barlow, the thanks of the Institute were accorded Prof. Miller for his valuable paper.

A NEW AREA OF COPPER-BEARING ROCKS IN THE EASTERN TOWNSHIPS OF QUEBEC.

The paper on the above subject by Mr. Jno. A. Dresser, was read by himself; it will be found on page 397 of this volume.

After the remarks of Major Leckie and of the President, the thanks of the Institute were accorded Mr. Dresser for his valuable paper.

ON THE NICKEL DEPOSITS OF NORWAY.

The paper on the above subject by Major Leckie, Sudbury, was read by himself. This will be found on page 401 of this volume.

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After the discussion of the paper by the President, Major Leckie, Mr. Obalski and Mr. Stevenson Brown, the thanks of the Institute were accorded Major Leckie for his valuable paper. The following papers were read by title and will be found in this volume, pages 410 and 422 respectively, "On the Occurrence and Development of Corundum in Ontario," by Mr. M. B. Baker, Kingston; "Notes on Some Western Coals," by Prof. J. C. Gwillim, Kingston, Ontario. These papers were presented to the Eastern Ontario Section of the Institute at meetings of the Section held at Kingston, Ontario, on the 26th November, 1903, and on February 5th, 1904.

The President then read the report of the scrutineers on the election of officers as follows:

"The scrutineers appointed to open the ballot box and count the votes cast for officers of the Institute beg to report that; Three ballots which were unsigned were rejected; the remaining ballots were all for the names presented by the nominating committee. The scrutineers therefore report that the officers elected for the year 1904-1905, in addition to these whose term of office has not expired, are:

President, Mr. Eugene Coste, E.M., Toronto.
Vice-President, Mr. E. B. Kirby, M.E., Rossland, B.C.
Treasurer, Mr. J. Stevenson Brown, Montreal.
Secretary, the late Mr. B. T. A. Bell, Ottawa.

COUNCIL MEMBERS:—

James McEvoy, Fernie, B.C.
W. F. Robertson, Victoria, B.C.
A. B. W. Hodges, Granby, B.C.
W. G. Miller, Toronto, Ont.
R. G. Leckie, Sudbury, Ont.
Jno. Blue, Eustis, Que.
Frank D. Adams, Montreal, Que.
Graham Fraser, North Sydney, C.B.

Respectfully submitted,

FREDERICK HOBART,
J. OBALSKI,
S. DILLON MILLS. } Scrutineers.

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Therefore the full list of officers and councillors of the Institute constituting the Board, now stands as follows, for the year 1904-1905.

OFFICERS AND COUNCIL, 1904-05.

PAST PRESIDENTS (OF THE BOARD, EX-OFFICIO).

Mr. John E. Hardman, S.B., M.E., Montreal, 1898-99.
Mr. Samuel S. Fowler, S.B., M.E., Nelson, B.C., 1900.
Mr. Chas. Fergie, M.E. Westville, N.S., 1901-02.

PRESIDENT.

Mr. Eugene Coste, E.M., Toronto, Ont.

VICE-PRESIDENTS.

Mr. Jno. B. Hobson, M.E., Bullion, B.C.
Mr. E. B. Kirby, M.E., Rossland, B.C.
Mr. Robt. E. Chambers, M.E., 295 Pr. Arthur St., Montreal, Que.
Mr. Geo. R. Smith, M.L.A., M.E., Thetford Mines, Que.

SECRETARY.

The late Mr. B. T. A. Bell.

TREASURER.

Mr. J. Stevenson Brown, Guardian Bldg., Montreal.

COUNCIL.

Mr. Jas. McEvoy, Fernie, B.C.
Mr. S. F. Parrish, Le Roi Mining Co., Rossland, B.C.
Mr. W. F. Robertson, Victoria, B.C.
Mr. A. B. W. Hodges, Grand Forks, B.C.
Prof. W. G. Miller, Toronto, Ont.
Major R. G. Leckie, Sudbury, Ont.
Mr. D. G. Kerr, C. & M.E., Craigmont, Ont.
Dr. W. L. Goodwin, School of Mining, Kingston, Ont.
Mr. Harry J. Williams, Thetford, Que.
Mr. Jno. Blue, Eustis, Que.
Dr. F. D. Adams, Montreal, Que.
Mr. F. Cirkel, Consulting Mining Engineer, Montreal.
Mr. Graham Fraser, North Sydney, C.B.
Mr. G. H. Duggan, C. E., Glace Bay, C.B.
Mr. Thos. Cantley, New Glasgow, N.S.
Dr. E. Gilpin, Jr., Deputy Commissioner of Mines, Halifax, N.S.

The President (Mr. Eugene Coste) briefly but warmly tendered his thanks to the members for their renewed mark of confidence in re-electing him to the honorable position of President of the Institute.

The meeting then adjourned.

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8TH SESSION, FRIDAY EVENING.

The members re-assembled at 8 p.m., the President (Mr. Coste) in the chair.

THE MINERAL PRODUCTION OF ONTARIO IN 1903.

The paper on the above subject by Mr. T. W. Gibson, Director Bureau of Mines of the Province of Ontario, was read by himself. This will be found on page 425 of this volume.

After the discussion of the paper by the President, Mr. Stevenson Brown, Mr. Morrison, Prof Miller, Mr. Thompson, Mr. Hobart, and Major Leckie, the thanks of the Institute were accorded Mr. Gibson for his valuable paper.

THE GEOLOGICAL SURVEY OF CANADA AS AN EDUCATIONAL INSTITUTION.

An address on the above subject by Prof. T. L. Walker, was delivered by himself. This address will be found on page 435 of this volume.

After a discussion of the subject by Dr. Adams, Mr. Craig, Dr. Parks, Prof. Montgomery, Mr. Stevenson Brown, Prof. Brock, Dr. Barlow, Major Leckie, Mr. Clark, K.C., Mr. Gibson, Prof. Walker and the President, the thanks of the Institute were accorded Prof. Walker for his valuable suggestions.

Mr. Stevenson Brown took the chair temporarily while the President (Mr. Eugene Coste) read his paper on

SUGGESTED IMPROVEMENTS TO THE MINING LAWS IN CANADA.

This paper will be found on page 450 of this volume.

After the discussion of the paper by Major Leckie, Mr. Thompson, Mr. Clark, Mr. Hardman, Mr. D. O'Connor, Mr. Gibson, the President, Mr. Jas. Walsh, Mr. Craig and Mr. Blum, the thanks of the Institute were accorded Mr. Coste for his rousing paper, which created considerable animation, and a great many of the members present evidently enjoyed this fitting climax to a very successful and lively meeting.

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The following additional papers were read by title and will be found on pages 480-495-500 and 505 of this volume.

On "Acid Making from Pyrrhotite," by E. A. Sjostedt, M.E., Sault Ste. Marie, Ont.

On "The Early History of Mining in the Sudbury District," by J. W. Evans, C.E., Deseronto, Ont.

On "The Special Features of Coal Mining in the Crow's Nest, B.C," by James McEvoy, M.E., Fernie, B.C.

On "Exhaust Steam Boiler Feed-Water Heaters," and on "Hot Water Pumps and Pumping," by W. D. L. Hardie, Lethbridge, N.W.T.

The meeting then adjourned.

The annual dinner, which was to have taken place as usual on the evening of the third day, and at which the Lieutenant-Governor of Ontario and many other prominent guests were to be present, was cancelled by decision of the Council, through respect to the memory of the deceased Secretary of the Institute.

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Journal of the Canadian Mining Institute, Vol. VII.

GENERAL ANNUAL MEETING, HELD IN TORONTO, 2nd, 3rd AND 4th MARCH, 1904.

Presidential Address.

By Eugene Coste, E.M., Toronto, Ont.

Gentlemen:—It becomes my pleasant duty, as president of the Canadian Mining Institute, to welcome you all to this our sixth annual meeting, and personally, permit me to also greet you all the more heartily as this is the first meeting of this Institute to take place in my native province of Ontario. In past years we have held our annual meetings in the good old city of Montreal, which by the special act of Parliament incorporating our Institute is designated as the place of our head office. Royal times did we have there and good lively discussions on many very important topics concerning our mining industries. But we propose, here in Toronto, to lag behind neither in contentment and good fellowship among ourselves nor in the sharp interest always shown in the papers presented by our members; the only fear we have is that our discussions on matters affecting our mining industries will not be as lively here, outside of the French-Canadian invigorating atmosphere. This would be a pity, but it, however, remains to be seen whether it will be so, and we can tell better after the meeting whether our fears in this respect were correct, or whether mining men, especially Canadians, are not always lively wherever they may be.

When this Institute was founded in 1898, it numbered sixty-six members from Quebec, and forty-four from Ontario, exclusive of student members, whilst at the end of last year our record shows sixty-nine members from Quebec and one hundred and eight from Ontario, exclusive of student members. To this much quicker and larger growth of membership in Ontario, is to be attributed in a great measure the fact that we are gathering in

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Toronto today; and it is an indication that the mining centre of Canada is becoming fashionable and is preparing to move west and north as further exemplified by the fact that we have now eleven members in the Yukon, while we had none there in 1898, and that we have now sixty-eight members in British Columbia, when we had only forty-two there in 1898. It is true, as an offset, that we have now from Nova Scotia thirty members instead of sixteen in 1898, but still it is clear that our Quebec and Maritime Province membership is (in point of number only) lagging behind the membership west of Montreal. No doubt this is only a natural result of the opening up of the western sections of the country, but still I thought that by mentioning the fact I might nevertheless stimulate our eastern members to renewed efforts in getting all the good mining engineers and mining men in their provinces to join our Institute in order to make of it a still more powerful factor in carrying out the purposes for which it was chartered by a Special Act of the Parliament of Canada. These purposes are well defined in the preamble of our Charter; they are unselfish and noble purposes; and, since this is our first meeting outside of Montreal, it seems a good opportunity to review briefly the past work of our Institute, as this review will show that we are living up to the patriotic, unselfish aims for which we got together some years ago, and are thereby greatly benefiting and promoting the development of the mining industries of Canada.

A little of the past history of the several mining organizations which preceded us is here necessary, since we are the successors of these bodies of mining men formerly organized separately in the different mining provinces, but which afterwards not only formed a federation, but even dissolved themselves subsequently into a larger and stronger Institute under a general charter from the Canadian Parliament to embrace mining engineers and mining men from the whole of the Dominion of Canada.

The following is a brief sketch of the evolution of these mining associations:

23rd January, 1891, General Mining Association, Province of Quebec, was formed.

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30th March, 1892, Mining Society of Nova Scotia was formed.

10th April, 1894, Ontario Mining Institute was formed.

January, 1896, Federated Canadian Mining Institute was formed.

4th March, 1898, Canadian Mining Institute was formed.

Before the organization of the Quebec Mining Association there was a small organization in Nova Scotia called the Gold-miners' Association of Nova Scotia, of which our present worthy secretary was the only honorary member. We must not overlook the Mica Miners' Association, which did some good work in collecting a large amount of data concerning the production, uses and markets for mica, nor the organization effected last year of the Provincial Mining Association of British Columbia, a very well organized body of all classes of the community in that province organized for protection and the betterment of mining legislation in British Columbia.

All these organizations have been a powerful factor for good.

First—Through their publications:

A list of the papers read before these bodies form quite an imposing and exceedingly creditable contribution to our mining literature; these papers and the discussions upon them have been published in pamphlets and handsome volumes, and have rendered an important service to the country in advertising our mineral resources and industries. This list of papers has just been published by our secretary by names of authors and subjects, and will be found very useful as a reference. A glance at it will illustrate the great diversity of the subjects treated, that is almost to say the great richness of Canada's various mining resources; and, a careful reading of the papers will convince one of the great value of this literature to the country.

I will only add here, that if a comparison is made between the publications of the Canadian Mining Institute as shown at the end of the appended list and the publications of "The Institution of Mining Engineers" of England, or of "The American Institute of Mining Engineers," it will be found that relatively, per capita

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of members, our papers are considerably more numerous and, as to their worth, we are, of course, too modest to speak, and leave it to others, but with confidence in the verdict.

Thus we see that the first object and purpose of this Institute as set down in our charter, viz.: "To promote the arts and sciences connected with the economical production of valuable minerals and metals, by means of meetings for the reading and discussion of technical papers and the subsequent distribution of such information as may be gained through the medium of publications," is very creditably carried out by the Institute. But if, in the short space of time of six years since the incorporation of the Institute, we have made such an excellent showing in the matter of publications, it is still more pleasing for me to record that these publications are improving very rapidly from year to year and that the last two volumes of our journal, volumes five and six, contain many more papers of a still higher and useful class than the preceding volumes, and that they are well and profusely illustrated.

I take renewed pleasure here in again recording and acknowledging with thanks, as President of the Institute, the generous assistance of the Dominion Government in granting us three thousand dollars per year during the last two years towards defraying the expenses of these publications and of the Institute in general. Thus the Government has recognized our Institute as of public utility, and has facilitated its growth and influence. In doing so, it has no doubt rendered a great public service to the country, as the mining engineers and mining men of Canada, together in a chartered strong organization, can do so much to make known, develop, utilize and protect its great mineral wealth, and the Canadian Mining Institute, composed of such men, has shown and will continue to prove, that it can be of the greatest service in these most important undertakings.

Second—But not only by the publication of technical papers read at its meetings can an Institute such as ours be of service to the country, but the Canadian Mining Institute as a body has still another very important mission to perform, and that is also defined

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in its charter as one of the purposes for which it was founded, thus, namely: "to take concerted action upon such matters as affect the mining and metallurgical industries of the Dominion of Canada."

This mission is all the more important that we are practically alone entrusted with it in Canada, since with the exception of the Mining Society of Nova Scotia and of the Provincial Mining Association of British Columbia, we are the only organized and incorporated body of mining engineers and mining men in the country, and, of course, the above provincial associations only represent their provinces in matters purely local, while the Canadian Mining Institute alone represents the mining interests of the entire Dominion of Canada, not excepting Nova Scotia or British Columbia, as almost every member of the above mentioned provincial associations is also a member of our Institute.

In the matter of the publication of technical papers we are sharing the duty and responsibility with other societies and with such Government institutions as the Geological Survey and the Provincial Mining Bureaus, but in all matters affecting the welfare of the material interests so dear to us of the mining and metallurgical industries, we repeat, this Institution is, in a very large measure, alone to raise a competent voice and to give an authoritative advice.

This protective mission or duty which, naturally an by its charter, devolves upon this Institute, was in fact the reason for its foundation as the first movement to form what is now the Canadian Mining Institute was prompted by the introduction of the Mercier Mining Act in Quebec, to oppose which, the Quebec Mining Association, our first parent, was organized early in 1891.

In looking over the report of one of the meetings held in this connection at the St. Lawrence Hall, Montreal, in October, 1890, we notice these significant remarks from one I need not introduce, namely:

"Honorable, now Sir, Wilfrid Laurier having been called upon by the chairman, said he had just dropped in to listen, and had no intention of making a speech. He was personally inter-

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ested in mining operations in the province, and although he would not go so far as to say that after mines had reached a certain stage of development they should not be made to yield some public revenue, still he felt that to impose any new burden upon what was yet a new industry would not only be detrimental but fatal. (Cheers.) He deprecated the introduction of politics into the matter. He need not tell them that he was a supporter of Mr. Mercier (laughter and applause), but he was nevertheless ready to join those present in demanding that an industry in which he was to some extent interested should be safeguarded. He fully believed that when the bearings of the subject were placed fairly and justly before the Government they would shrink from the adoption of legislation injurious to the interest of the province."

In the above language of our distinguished Premier we must ever be ready to safeguard the best interest of the industries in which we are vitally concerned by fairly and justly placing before our Governments all the bearings of the different subjects arising in respect of these industries, and, in doing so, we are only abiding by and fulfilling the provisions of our Charter of Incorporation. Have we done so in the past, and what is the record of the Institute in that respect?

In the Appendix to this address will be found a list of all the discussions, resolutions and actions of the Institute on matters affecting the mining and metallurgical industries of the country, as these took place from year to year. It is not a very long list, not as long as the list of our papers, as we are, of course, much more interested in technical matters during our annual meetings, but a study of it and a careful reading of all the discussions clearly shows that we have nevertheless been alive to the safeguarding of the best interests of the industries we represent, and according to the precept of our Right Honorable Premier in the language above quoted, by presenting our cases fairly and justly. The very best proof indeed of the constant justice and fairness of our course is that almost every recommendation made by this Institute has been adopted by our different Provincial Governments or by the

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Dominion Government. For instance, in the three following important matters:

First.—As this Institute strongly advocated, export duties on nickel-copper ores and mattes or on any other mineral were never imposed by the Dominion Government, notwithstanding that this was advocated by many in the press and everywhere, and even was asked of the Dominion Government in an order-in-Council approved by the Lieutenant-Governor of Ontario on the 24th November, 1899.

Second.—Notwithstanding that a law was passed in the Ontario Legislature in the session of 1900 empowering the Lieutenant-Governor-in-Council to impose by proclamation certain heavy taxes on nickel and nickel-copper ores and mattes, and to remit these taxes in cases in which these ores or mattes were completely refined in Canada, yet the provisions of this Bill were never proclaimed in force, and time has shown that the members of this Institute were on the just and right side in opposing strongly such an interference with the industrial independence of the mining community.

Third.—And again the Yukon royalty of 10 per cent. of the gross gold production placed by the Dominion Government has been reduced to a 2½ per cent. royalty now collected on the gold exported as strongly recommended by us in one of our memorials to the Government.

The above are our most important victories, but our influence has also contributed largely to many lesser achievements such as the successive defeats of a well known bill brought forward with persistence year after year, and which we as persistently opposed, because we considered that it would restrict and confine the practice of engineering within certain limits altogether too narrow; also the defeat of the Alien Labor Law in British Columbia and of the Eight Hour Law in the same province. To this influence of the Institute and to our discussion on these matters is also due in no small degree the making of good roads in the Yukon, many improvements in the mining regulations of that district, the exemption of municipal taxation for the mineral properties of

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Quebec Province for another period of ten years from 1899, the placing on the free list of gold dredging and other mining machinery, etc.

There is also another subject of very great importance to the mining interests of this country to which this Institute has wisely devoted considerable time and attention on many occasions, and in which, I am very glad to be able to record, our influence has also been the means of affecting substantial advance and progress. I refer to the question of what should the Dominion Government do in "Aid to Mining."

So far the Geological Survey of Canada has been almost the only "Aid to Mining" given by the Dominion Government. This Institute has always shown its appreciation of the good work of many prominent members of the Geological Survey and has even advocated, with some success, the payment of larger salaries to members of such a technical branch of the service. It has also often recommended larger, better and safer accommodations for the offices of the Survey and for the very valuable collections of its museum, and it is very gratifying to know that this is at last being provided for in an entirely new, large building, the ground for which has been acquired by the Government in Ottawa, and the plans of which have been prepared and decided on, and which is to be built immediately. Yet, this Institute has felt and has fairly but firmly expressed during the important and lengthy discussions which took place on this subject during our annual meeting of 1902, that the Geological Survey as then organized and conducted was entirely unable to cover all the ground which the "National Importance of Mining," and the many important interests served thereby, now need and demand in such a large and rapidly growing country as Canada, so rich in mineral resources of all kinds and so much of which is yet so entirely new and even unknown that it requires many thorough explorations, surveys and studies. We pointed out that the Geological Survey Department in charge of this work had not grown with the country, that it had practically the same appropriation year after year for many years, and, therefore, that it was only natural if it was

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not keeping pace with the rapid mining and metallurgical developments of this country and if it was lacking in many of the branches necessary for its complete usefulness. That it needed, therefore, to be re-organized and extended and converted into a "Department of Mines and Geological Survey."

At the end of the discussions, which should be carefully read in our Volume VI. by all who take an interest in the development of our mineral resources, it was unanimously resolved: "That the Canadian Mining Institute, in annual session assembled, desires to direct the attention of the Federal Government to the magnitude and importance of our mining industry which during recent years has developed so rapidly; and respectfully urges an increase of Government aid wherever possible and the establishment of a strong and practical Department of Mines or of a Department which shall be devoted to the interests of the mining and metallurgical industries and which shall include the Geological Survey and all other necessary branches."

These necessary branches were clearly pointed out during the discussions to be:

Administrative branch.
Geological Survey, Paleontological and Botanical branch.
Geographical and Topographical branch.
Mining Geological Survey and Monograph branch.
Statistical, Economic and Commercial Mining branch.
Chemical and Metallurgical branch.

I take pleasure in recording that the Dominion Government, through the Honorable the Minister of the Interior, has been gradually working on the lines of the above resolution and suggestions and in complimenting the new geographical branch on the excellence of its work newly published, and we have no doubt that the other branches which have lately or are being organized will soon be able to make as creditable a showing.

This is the age of specialization, as we all know, and necessarily so since every branch of science, industry, commerce or anything else is getting to be such a vast and complex subject in itself, that the best specialists are none too good often to stand

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the sharp light and competition of such rapidly advancing progress. Therefore, it is only natural that the conclusions arrived at by members of this Institute after exhaustive studies and discussions on the subject of Government "Aid to Mining" should have been that the work of the Department of the Dominion Government specially devoted to the interests of the mining and metallurgical industries of the country should be specialized in different branches, each with as competent a head as it is possible to secure, and all under the direction of one of the cabinet ministers, whether this cabinet minister be named minister of mines or minister of the interior, is a matter of little moment to us as long as the important work under his charge, in which we are all vitally interested, is thoroughly and systematically done.

The work of such a department of the Dominion Government, as it was well pointed out during our discussions, would not interfere in the least with the mining rights and the work in that connection of our different provinces which have under their charge the making and administration of the mining laws of these provinces; the selling thereby or leasing of the mineral lands, the inspection of the mines for the due protection of the safety of the miners and the prevention of waste, the keeping of proper maps, plans and records of their mines, the collection of dues, licenses, taxes or royalties on the mines of their provinces; the collection of mineral and metallurgical statistics, the care of helping and fostering technical education, the provincial public assay offices, the making of better roads and other means of transportation in their mining districts, the establishment of custom concentration and reduction works, the assistance in deep sinking or in testing deposits by diamond drills or otherwise, the prompt issuance of notes, papers or bulletins on the newly discovered mineral districts of the province, etc.

There is only one more question of importance which has engaged the attention of our Institute, especially at our last annual meeting, which I need to record here to make this review complete, and that is the subject of mineral statistics.

This Institute has naturally always attached the greatest

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importance to a thorough statistical knowledge of the progress of our mining and allied industries from year to year, and many presentations of such statistics and discussions upon them have taken place at our meetings. From all of which it is quite clear that the correctness of such records, their prompt publication, their fulness and their clearness is as important to us and to the success of our mining and allied industries as a true compass is to a navigator; in fact, as entirely indispensable to us as the needle is to that navigator. But unfortunately the mining bureaus of the different provinces and of the Geological Survey, who collect and publish these statistical records for their provinces and for the Dominion respectively, have adopted widely different standards of value and even different systems of compilation and presentation which have so far rendered these records of very much less practical value to the members of this Institute and to the important interests of the country to be served thereby as they would otherwise have been.

Taking this into consideration and after prominently discussing the subject at our last annual meeting we appointed a large committee of our members, including all the heads of the different official mining bureaus of the country, who are all members of our Institute, and who very kindly volunteered to assist our efforts in this direction of uniformity in these records. This committee has been at work, and will continue its labor until it is able to report the accomplishment of the important results sought after.

In closing this imperfect review of the work of the Canadian Mining Institute in the past I beg to thank you all, gentlemen, for your kind attention, and I will now formally declare the 1904 general meeting of the Institute open for the reading of papers and the transaction of business.

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APPENDIX.

DISCUSSIONS, RESOLUTIONS AND ACTIONS OF THE CANADIAN MINING INSTITUTE, YEARS 1899 TO 1903, INCLUSIVE.

ANNUAL MEETING, MARCH, 1899.

A petition respecting the Yukon Mining regulations forwarded to us from the Incorporated London Chamber of Mines and asking the help of this Institute in obtaining a number of changes in these regulations, especially with regard to the 10 per cent. royalty, was considered, but, as the secretary of the Institute stated that the Dominion Government had emphatically declared at that time that they would not make any rebate of that royalty it was agreed that nothing could be done by the Institute at that time.

Discussion on the work of the Geological Survey and resolution appreciating the services rendered to the mining interests of Canada by the work of the Geological Survey and urging upon the Government the necessity of giving further financial support to that department with a view to the increase of its work in the mining districts, and also of more adequately remunerating the services of the members of its technical staff.

Resolution authorizing the council of the Institute to impress the Provincial Governments with the necessity of maintaining their mining bureaus in a high state of efficiency and with the desirability of these bureaus adopting a more uniform standard of compilation of mining statistics.

Opposition to a bill of the Canadian Society of Civil Engineers restricting the rights of engineers to practice unless they became members of that society; and authority conferred on the council of the Institute to take the necessary steps to defeat the object of this bill in so far as it affects or relates to mining interests.

Resolution presented by the British Columbia members urging upon the Dominion Government the desirability of establishing a mint in British Columbia; postponement of the question for further consideration.

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SUMMER MEETING, BRITISH COLUMBIA, 1899.

Resolution strongly disapproving of the passing of an Eight Hour Law by the British Columbia Legislature and asking for its repeal.

ANNUAL MEETING, MARCH, 1900.

Discussion on mining laws during which the need of a mining law in the Yukon and other territories of the Dominion was pointed out.

Discussion during which the small size of the placer claims in British Columbia is pointed out and condemned and during which also the very bad results of the Alien Labor Law of British Columbia in the Atlin district are pointed out.

Discussion of the conditions then existing in the Klondike during which the building of roads in that district is strongly advocated as a necessity for the freer and cheaper transportation of supplies and of mining machineries and for the good of the district in general.

Discussion on the 10 per cent. Dominion Government royalty on the gross output of gold in the Yukon during which the onerous nature of that royalty is strongly brought out and condemned; the Institute petitions the Dominion Government for the reduction of that royalty to 2 per cent., for the collection of it on the gold as exported out of that district, and for the collection of correct statistics of the gold production of that district.

Discussion on the nickel question and on export duties during which many of the members strongly disapproved of an Order-in-Council passed by the Ontario Government (24th November, 1899) asking the Dominion Government to impose export duties on nickel and nickel-copper ores and matte and proposing not to grant nickel-copper mining land in the future except under a condition providing for the cancellation of the grants in cases in which the nickel and nickel-copper ores and mattes were not refined in the province; the meeting referred the matter to the Council with full power to act as they thought best.

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ANNUAL MEETING, MARCH, 1901.

A delegation of members of the Institute is appointed to urge upon the Government the great need of further accommodations for the museum and offices of the Geological Survey, and also to advise the payment of larger salaries to the technical officers of the Survey in order to retain and secure the services of the best men in the country.

Institute recommends that Dr. F. D. Adams, Logan Professor of Geology at McGill, be appointed successor to the late Dr. Geo. M. Dawson, as director of the Geological Survey of Canada.

Discussion on "Company Law," during which the provisions of the "Company Law" of England and of the Dominion to prevent the selling of stock below par are commended.

The secretary of the Institute reports that during the previous year (in April, 1900) he and other members of the Institute, on behalf of the Institute, opposed the passage of the following bill introduced in the Legislature of Ontario by the Hon. the Commissioner of Crown Lands, namely: "An Act to amend the Mines Act." This Act provided that anyone mining iron ores, zinc ores, copper ores, nickel ores, nickel-copper ores or any other ores or minerals in the province was to pay in the future very heavy taxes on the gross output of these minerals; these taxes to be remitted at the end of the year to those smelting and refining metals from these ores in Canada. The secretary adds that after the strong recommendations made on behalf of the Institute against this Act, it was greatly modified and all its provisions were struck off in respect to all ores and minerals except nickel and nickel-copper ores and mattes, and finally that an amended bill was passed by the Legislature (63 Vic. Cap. 13) in which:

First.—The Lieutenant-Governor-in-Council was authorized to put into force and effect by proclamation certain sections of the bill by which the following very heavy taxes upon the gross output of nickel and nickel-copper ores and mattes would be imposed, namely:

(*a*) For ores of nickel $10 per ton, or $60 per ton if partly treated or reduced.

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(*b*) For ores of copper and nickel combined $7 per ton, or $50 per ton if partly treated or reduced.

Second.—The Lieutenant-Governor-in-Council was also authorized to remit or refund these taxes in part or in full "where ores or mineral that have been mined, raised, or won in the province are smelted or otherwise treated in the Dominion of Canada by any process so as to yield fine metal or any other form of product of such ores or minerals suitable for direct use in the arts without further treatment."

The provisions of the above bill were fortunately never proclaimed into force and effect by the Lieutenant-Governor-in-Council, thanks, to a large extent, to the efforts of this Institute.

ANNUAL MEETING, MARCH, 1902.

The bill of the Canadian Society of Civil Engineers restricting the practice of engineering in Canada to members of their society is again before the Institute with some amendments, but after due consideration it is again decided to oppose it, and the secretary is instructed to wire the chairman of the Private Bills Committee of the Ontario and Manitoba Legislature protesting against the passage of any such legislation: "Since it gives powers to said society that should not be given to any one branch or section in the present condition of the engineering profession. Such powers should be retained by the Government itself or reserved for a society or association representative of the whole profession."

A very good discussion took place on "The National Importance of Mining," and how may the government of a country promote the interests of mining and the development of its mineral resources. At the end of this discussion the following resolution was adopted:

"That the Canadian Mining Institute, in annual session assembled, desires to direct the attention of the Federal Government to the magnitude and importance of our mining industry which during recent years has developed so rapidly; and respectfully urges an increase of government aid wherever possible and

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the establishment of a strong and practical department of mines or of a department which shall be devoted to the interests of the mining and metallurgical industries and which shall include the Geological Survey and all other necessary branches."

ANNUAL MEETING, MARCH, 1903.

Discussion on mining statistics and appointment of a committee of the Institute to report at the next annual meeting and to suggest if possible a system of presenting mineral and metallurgical statistics acceptable to all the different Government Mining Bureaus in Canada in order that complete uniformity be obtained in these important records of the Dominion and of the different provinces.

After discussion it was resolved that this Institute, through its officers, urge on the Government of the Province of Quebec the necessity and importance of establishing in the city of Montreal a branch office of the Department of Mines.

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NOTES ON MINING AND SMELTING IN THE BOUNDA DISTRICT, B.C.

By Frederic Keffer, M.E., Greenwood, B.C.

Toronto Meeting, March, 1904.

Two years ago the writer contributed a paper on mining grade ores as carried on at the Mother Lode mine in the Bound District. It is the purpose of the present paper to briefly developments of the system particularly as regards the quarry and economical handling of ores, and also to touch upon cer features connected with smelting operations.

At the mine in question the series of quarries has been tended until there are at present four raises to the surface from main tunnel, with a fifth in course of driving. In so far as possi the tops of these raises are maintained funnel-shape so as to red handling to a minimum. While the pits remained shallow it was easy matter to remove barren or very poor rock by loading into cars and tramming to waste dumps; but as the funnel syst developed it became quite inadvisable to remove any except la bodies of waste, for the cost of removal had become greater th the cost of smelting. Experience has shown, however, that evil effects of these smaller bodies of waste have been more th offset by the improvement in the general run of the ore bo due to lesser quantities of partially leached surface rock bei included. So that the average copper contents of the 135,5 tons mined in 1902 was appreciably less per ton than that of t 137,800 tons mined in 1903.

In places, however, large dykes of epidote and alkali porphyr and occasionally isolated bodies of limestone, occur, which a removed by blasting into raises, all the ore having been previous withdrawn.

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The crusher plant located at the entrance of the quarry tunnel has taken care of quarry ore alone, that from the stopes being crushed by a Gates machine located at head of shaft.

Work is now being carried forward to consolidate the crushing plants and to do away with the Gates machine, which, although a No. 5 size, is entirely inadequate to the demands made upon it.

To this end a tunnel is being driven to intersect the main shaft on the same level as the quarry tunnel. At the shaft will be located a very large pocket, and this will discharge into 5 ton skips which will replace the cages now used. The skips will empty into a bin at the head of the shaft, thence passing to either one of a pair of Jenckes-Farrell crushers, each crusher having a jaw opening of 2 x 3 feet. These crushers will be driven by a pair of 100 h.p. engines so arranged that either engine can drive either crusher, this to eliminate all chance of stoppages through breakdowns in either engines or crushers—stoppages which past experience has shown to be inevitable as well as costly. The crushed ore will be conveyed by a Robins belt to the main ore bins. All car dumping and opening of bin and pocket gates will be done with compressed air. The same skips and crushers will, of course, serve all levels in the mine.

Although the ore will need to be hauled further under the new arrangement, crushing costs will be lowered. For the reason that aside from stoppages for repairs to machinery being practically eliminated, the provisions of capacious pockets and shaft bins insure steady operation of crusher, which machine if constantly supplied with ore can crush the smelter day's run in a single shift, instead of this work taking one and a half shifts as at present.

Jamming of elevator buckets, constant repairs to them, and their clogging with frozen fines in winter will be eliminated—all serious drawbacks to rapid work. The short tunnel to shaft will also become the general entrance to mine, both for men (whose houses are all on this level) and for materials from shops and storehouses.

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The main features of this work are shown in the accompanying plan.

In the matter of power, the cost of this item at the mine has been greatly reduced through the consolidation of power plant, and the driving of all machinery with compressed air. The 100 h.p. crusher engine formerly steam driven from boilers near by, now uses compressed air, which is heated to a considerable degree just before entering engine. This expedient has effected a direct saving in labor and fuel of from 5 to 7 cents per ton of ore crushed. Air is furnished by a cross compound condensing Corliss compressor, capacity 3,200 feet free air per minute. A pair of boilers located near crushers and hoist can furnish steam on short notice should the compressor machinery break down, thus guarding against stoppages through this cause.

From a smelting standpoint, the ores of the larger Boundary properties have as a rule grown less basic as the workings have extended and deepened. That is to say, the proportion of iron oxide ores to the whole ore body has sensibly diminished, there being no great change in the amount of other base. Whether this reduced proportion of base to acid is to remain permanent, it is (at least in the case of the Mother Lode mine) quite impossible to predict. Long experience in mining these deposits has shown that it is impossible to make safe predictions as to occurrence of zones of mineralization, new ore bodies being frequently found in unexpected places. On the 200 level of this mine there have been found considerably less oxide of iron ores than in either the quarries or the 300 level. The iron oxides of this latter level are uniformly of higher grade than those of the quarries, carrying more copper and gold, and do not appear to be directly connected with the upper deposits, although this is not absolutely proven. No exploratory work has been done beneath the 300 level (which is about 500 feet under the highest croppings of the ore).

A considerable body of iron oxide ore is at the mouth of the main tunnel, but no work has been done on it owing to close proximity of the crusher plant.

This change in the basic character of the ore is illustrated by the following average slag analyses, taken over corresponding

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periods, 1901, 2 and 3. The small tonnage of foreign ores treated affect the assays somewhat, but not materially.

Year.	Silica.	Iron.	Lime.	Total
1901	33.2%	28.5%	20.6	82.3
1902	40.5	22.2	20.2	82.9
1903	42.7	20.4	20.2	83.3

With slags running in silica from 40 to 43 per cent., and with matte at 40 to 45 per cent. copper, it is found that the furnaces can be maintained in good running condition, and slag losses kept within proper limits.

Therefore, to guard against possible scarcity of iron fluxes it has become general practice to conserve the iron ores of the mines, using only sufficient to keep slags within bounds above indicated.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MILLER—The district referred to by Mr. Keffer is comparatively new, but already in the transactions of the Institute we have three papers dealing with it, showing the interest which is taken in the boundary district. I may mention that there are two or three mining propositions in Ontario in which the ore will have to be handled in the manner proposed by Mr. Keffer, if success is to be made of them. In this connection Mr. Keffer's paper will be of great use in this province. We have one of the most complete compressed air plants in connection with mining that is to be found in America located in this province, and Mr. Keffer's experience will therefore be very useful to us.

MR. BROCK—The district in which the Mother Lode lies is rather unique in respect to the size of the low grade ore bodies and the cheapness with which they can be worked and smelted. Besides the mine of which Mr. Keffer is manager, there are a number of other large producers. Of these the best known example is the Knobhill-Ironsides, which is now worked on a very extensive scale. It is situated at Pheonix, about five miles in a direct line from the Mother Lode. It, too, is worked by a system

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of open quarrying combined with underground mining. In the large quarries steam shovels are used to load ore directly into cars.

The smelting plant at Grand Forks, consisting of a battery of six furnaces and converters, has a capacity of over 2,000 tons per day, which the mine can more than supply. The ore here, as in the Mother Lode falls mineralogically and chemically into three classes; 1st, that rich in magnetite; 2nd, that rich in lime carbonate, and 3rd, that rich in garnet, epidote and similar silicates. By mining each quality of ore in the proper quantities and judiciously mixing, a perfect smelt is obtained without the addition of any foreign flux. The raw, unsorted, unroasted ore, with a little coke, is charged directly into the furnaces, the molten matte carried by electric cranes to the converters to be run out as blister copper. To the self-fluxing character of the ore and the skillful management is due the fact that this district holds the American record for cheap smelting. It may be a matter of surprise to some of you to learn that a single mine is producing half a million tons of ore a year, also that the district as a whole is producing the copper mined in Canada, and that all the ore is now, or shortly will be, converted to blister copper on the spot.

There are similar low grade ores in other parts of the country, and the mining men owe a debt of gratitude to such men as Mr. Keffer, the pioneers in mining and treatment of these ores, who are evolving a process for successfully operating such low grade bodies, and are freely making public the results of their experience for the guidance of others. It means that in other parts of the province or the Dominion similar low grade bodies can be exploited systematically and with little uncertainty as to the result.

THE PRESIDENT—There is no doubt that we have in the Boundary District of British Columbia enormous deposits of minerals which are very valuable to the country. I was glad to notice the other day as a practical illustration of the value of these ores that one of the smelters there lately declared its first dividend. That is about as good a practical proof as we can have of the value of the ores of that district.

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Journal of the Canadian Mining Institute, Vol. VII.

THE ORE DEPOSITS OF ROSSLAND, BRITISH COLUMBIA.

By Edmund B. Kirby, E.M., Rossland, B.C.

(Illustrated by four Maps.)

Toronto Meeting, March, 1904.

The Rossland mining district began active production in 1894. Its total yield up to January 1st, 1904, is 1,620,540 tons of smelting ore, containing about $26,000,000 gross value, or $16.00 per ton in gold, silver and copper.

This tonnage was derived from the following mines:

	Approximate Tonnage.
Le Roi	974,785
War Eagle	240,455
Centre Star	229,648
Le Roi No. 2 (Josie & No. 1 Mines)	115,007
Iron Mask	17,655
Rossland Great Western-Nickel Plate	12,331
Columbia-Kootenay	7,790
Velvet	5,416
Jumbo	4,395
Giant	4,344
I.X.L.	2,900
Miscellaneous	2,447
Evening Star	1,500
Spitzee	900
Monte Cristo	400
White Bear	302
Homestake	140
Virginia	100
Portland	25
	1,620,540 tons, Est. Val. $25,816,342. Average. $16.00.

The ore is transported to the Columbia river over two competing lines of railway, and supplies extensive smelting works at the town of Trail and at the town of Northport. These towns together with a population of about 6,000 in Rossland, are thus supported by the mines.

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GEOLOGICAL POSITION.

The geological position of these ore deposits is shown by map I, which is a slightly modified copy of a map by the Geological Survey of Canada, from studies by Mr. R. G. McConnell. The elongated oval area of gabbro is surrounded by a border of varying width of augite and uralite porphyrites and fine grained green diabases. The transition from the gabbro to the porphyrites is not well defined, and they are both from the same magma. Beyond the above border come alternating series of porphyrites, tuffs and slates, and beyond these are agglomerates.

The basic coarse crystalline and plutonic gabbro thus surrounded by borders which become more acidic and finely crystalline, and finally pass into volcanic breccia and tuffs, indicates an ancient volcano centre. The gabbro area is the main plug or neck of lava crystallized at great depths and exposed by deep erosion. Its great age is indicated by this erosion and by the numerous alterations in the rock structure and in the rock minerals.

The active mining has been carried on not within the gabbro area but outside of it and in the porphyrites surrounding its western end. The principal mines are all included in the small group of claims shown near the edge of the gabbro and located on the flank of Red Mountain above the town of Rossland. Map No. II is a horizontal section through this group of claims at the approximate elevation of 3,530 feet above sea level. It shows the structure details exposed by the workings of the Le Roi, Centre Star, War Eagle, Josie, Number One and Iron Mask mines. These mines aggregate some 20 miles of total workings, and the principal depths attained are those of the War Eagle, 1,615 feet measured on the vein; the Le Roi, 1,361 feet, and the Centre Star, 1,289 feet.

On the west of these claims there is a belt of fine grained eruptives, probably porphyrites, which are in a schistose condition; having been so plated by pressure as to frequently resemble shale.

COUNTRY ROCK OF MINES.

Within the area of the claims the prevailing rock is evidently

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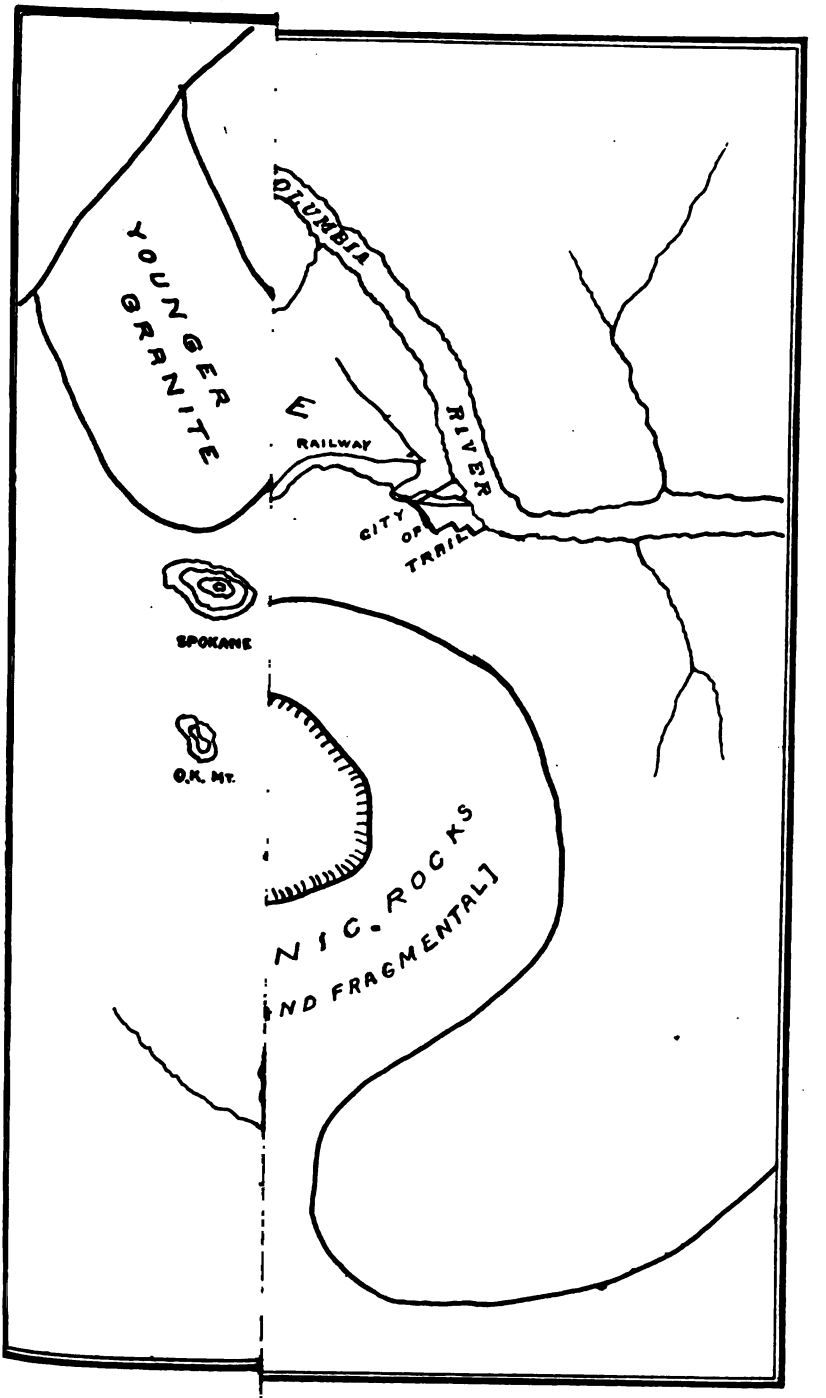

MAP Nº 1

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all from the same magma, but shows innumerable variations in rate of cooling and degree of metamorphism. It is mainly composed of plagioclase feldspars and pyroxene, generally in about equal proportions, but towards the gabbro area, bodies of pure pyroxenite are occasionally encountered. There is usually a small proportion of orthoclase feldspar and sometimes hornblende, and some observers have noted the fact that these appear more frequently towards the west. The rock appears to be holocrystalline and more or less porphyritic. The crystals may be either microscopic or as large as, say, five mm., while one or two mm. is a common limit. The feldspars are more or less altered to a turbid or porcelain-like appearance, while the pyroxenes are partially transformed to fibrous minerals of the uralite group. In strongly altered places, and especially within the veins, the rock is frequently colored brown from microscopic crystals of secondary biotite.

Although varying considerably in different places, specimens of this rock have generally been determined by microscopical observers as augite porphyrite, and it certainly belongs to the gabbro group, differing from the central area mainly in relative time and rate of cooling. Broadly speaking, the size of crystals tends to increase towards that area, and coarse crystalline masses are more frequently encountered, while in the other direction the structure becomes more fine grained.

DIKES.

This country rock is cut by innumerable dikes which require detailed comparison and determination by the microscope. Generally speaking they appear to be mica traps (perhaps kersantites) and altered basalts (perhaps melaphyre). The latter are often greatly decomposed.

The general direction of the parallel fractures has been north 10°W. with dips which are either vertical or very steep to the east. Their detailed fluctuations in strike and dip and the way in which they branch, unite and re-branch are clearly shown by the map. As explained hereafter, they probably belong to at least two periods, one before and the other after the ore deposition. Occasional belts of special crystallization in the country rock

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indicate dikes of an earlier date, which have since become cemented with the country rock and jointed to correspond with it. These have not been mapped.

THE VEINS.

These are shear zone fissures consisting of a series of parallel platings of the rock produced by shearing under high compression. In the Centre Star-Le Roi vein, in which the shear zone is most typically developed, this series of platings is 20 to 40 feet wide and dips about 70° to the northwest. The Josie vein is parallel; but the Centre Star north vein, the War Eagle and Iron Mask veins are branches from the Centre Star-Le Roi vein. Their positions and dips are shown upon the maps. The three latter veins also exhibit many of the characteristics of ordinary fissures and thus appear to have been formed under a less degree of compressive shear.

The ore consists of country rock more or less replaced or impregnated by pyrrhotite, accompanied in places by small proportions of chalcopyrite, pyrite, arsenopyrite and quartz. The pyrrhotite when it occurs by itself even in solid masses carries but little gold, say, from 50 cents to $3.00 per ton. The chalcopyrite is the principal carrier of gold, and ore of commercial value occurs only in those localities where chalcopyrite, pyrite and arsenopyrite have been deposited with the pyrrhotite. The manner in which these minerals occur within the interstices of the pyrrhotite, and the fact that continuous masses of pyrrhotite ore are impregnated in some places and barren in others, proves the later deposition of these valuable minerals. They have been introduced after most of the pyrrhotite was in place, although occasional occurrences of chalcopyrite and pyrrhotite in quartz point to the possibility of some contemporaneous deposition. The change from one deposition to another was probably gradual. A small proportion of the gold in the ore is native in the form of small grains and scales. The fact that oxidation extends only a few feet below the surface, while the proportion of metallics seems to average much the same even in ore shipments from the lower levels, suggests original deposition in this form. No data have

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been collected, however, to indicate whether it was contemporaneous with the pyrrhotite formation.

The average proportions of gold, silver, copper and total sulphides in a grade of, say, $16.00 full assay value are as follows:

Metal or Mineral.	Average Centre Star Ore.	Average War Eagle Ore, representing also Ore of Number One, Josie, Le Roi.
Gold (oz.)	0.63	0.54
Silver (oz.)	0.45	1.10
Copper (per cent.)	1.17	1.88
Sulphide Minerals (per cent.)	25.7	23.2

In various places the pyrrhotite seems to be accompanied by a little nickel and cobalt, specimen analyses ranging from 0.13 to 0.65 per cent. nickel, and from a trace to 0.59 per cent. cobalt.

FAULTS.

These have an average direction which corresponds to the dike system, with dips ranging from vertical to 50° easterly. Out of the great number of fractures studied and surveyed only the principal faults have been plotted, *i.e.*, those fractures which appear to have affected the veins by well defined displacements or by acting as barriers to mineral solutions. The map gives only a partial idea of the way the main faults branch in strike and in dip, and of the numerous minor interlacing fractures which connect them. In certain localities it will be seen that the ground is hopelessly shattered.

The faults are frequently not plainly marked, having no clay filling and at most only a small thickness of comminuted material. They frequently consist of a zone or series of close fractures, some of which are better marked than the others, and these fracture planes often interweave in such a manner that local measurements of their strike and dip are deceptive, and these can be determined only by comparison with other workings. As

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a general rule, the faults appear to have been too tightly compressed to give access to mineral solutions, and those existing during the deposition period have therefore tended to act as barriers to the flow of these solutions.

Since individual faults often cross dikes at sharp angles in strike and dip, a fault frequently breaks along a dike for considerable distances. Hence in many cases of vein displacement it is impossible to say how much of the total amount has been due to the dike fracture, and how much to subsequent fault fractures accompanying it. In most cases where dikes are not accompanied by plainly marked fracture planes the displacement is so small as to indicate that the fault system and not the dike has probably been responsible for most of the shifting.

The sharp angles at which the faults cut the War Eagle vein have tended to produce overlaps of the vein, which is most clearly illustrated by its intersections with fault (E) on upper levels.

The Josie and the Centre Star-Le Roi veins being crossed more squarely by the fault system, afford the best indications of its effects. The Josie dike, or more probably an undetermined fault accompanying this dike, have caused a displacement, which is indicated in the Josie and Number One vein to be a north throw going east. Proceeding east from fault to fault they are found to have the same throw up the faults (I and J) at the junction of the Le Roi-Centre Star territory, after which the steps occur in the other direction, with a throw to the south. On reaching fault (Q) a north throw is again encountered, and the steps to fault (T) are then south, north, north. The large scale reversal of stepping in both directions from faults (I and J) indicates a lifting of the blocks from this centre, the possibility of which is borne out by various connections of the fractures between faults (H) and (K), indicated in lower workings. As explained hereafter, much of the faulting occurred after the ore deposition and also at a later date than the dike formation.

DISTRIBUTION OF ORE AND ORE SHOOTS.

The pyrrhotite mineralization has been very abundantly distributed through the larger veins, but the subsequent deposition

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of gold and copper bearing minerals has been more localized, occurring in the more favorable places. The bodies of valuable ore thus formed are sometimes lenses, tapering out at the edges, and sometimes blocks terminating against faults or dikes. These ore bodies are found distributed within more limited portions of the vein area, which in the practical sense thus constitute the ore shoots, and indicate those portions of the area to which the gold and copper bearing solutions had the best access. The shoots are upon such a large scale and of such irregular form that their shape and limits have been developed very slowly, and the largest and best defined up to the present date are those of the War Eagle, Centre Star and Le Roi mines.

The War Eagle shoot has a dimension of 300 to 450 feet along the vein, and an almost perpendicular trend upon its plane. It is so located that its median line roughly coincides with the line of the main shaft.

The Centre Star main shoot is located in the space between the shaft and the Le Roi end line, and appears to have a dimension of 300 to 500 feet along the vein, with a steep trend to the east. The Centre Star east ore shoot is several hundred feet east of the shaft, but has not yet been sufficiently developed to determine its length along the vein or its trend, although the latter now appears to be either perpendicular or very steep towards the east.

The Le Roi ore shoot on the 350 foot level stands near the east end of the claim, as shown on the map, and descends perpendicularly, then assuming a westward trend. A little below the plane of the map it stretches out so as to include the entire distance between the Josie dike and fault (I), as illustrated by map III, of the Le Roi 700-foot level. The structure of the shoots and of the pay ore bodies within these shoots everywhere points to the conclusion that their location and shape are due entirely to the accidental conditions directing the upward flow of the mineral bearing solutions.

The marked difference between the proportions of gold, silver and copper in the Centre Star ore shoots and those of the other mines suggest that the solutions in the Centre Star came from

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a different region than those which furnished the other deposits. The fact that the Centre Star was somewhat nearer to the volcanic centre than the others, and that its ore shoots trend in that direction, may account for this.

These shear zone fissures, more or less shattered by repeated movements, have afforded permeable channels for the ascending mineral solutions, which have penetrated and decomposed the country rock, replacing its rock minerals wholly or partially by metallic minerals. In places the entire width of the shear zone has thus been transformed into ore, while in other places the mineralization has been narrow. The solutions have frequently jumped across from one set of plating fissures to another, shifting the pay streak from the hanging to the foot side, or to intermediate positions, as the case may be. In the Centre Star-Le Roi vein the foot wall fissure is the one which is the most regular and distinct, and is marked by a vein of small interlacing calcite seams, which has been found a very reliable indicator of the position of the vein. As a rule, the heaviest ore deposition has taken place near this foot wall, and mineralization extends to irregular distances on the hanging side, gradually fading into the country rock. In the War Eagle vein the hanging wall is generally the most distinct and best mineralized, with irregular extension into the foot wall side.

While many of the dikes and faults merely occasion small displacements, with no effect upon the mineralization, a number of them evidently occurred before this mineralization was begun, or at least before its completion, and acting as partial barriers to the flow have so deflected the solutions as to greatly increase the deposition on one side, although they have not themselves been mineralized. Map IV of a portion of the War Eagle 6th level, illustrates the way in which solutions rising through the fractured ground, caused by a fork in the vein, have been stopped by a large dike, and were so deflected and accumulated in rising along its under side as to produce exceptionally large and rich ore bodies. In the Josie vein the tramway dike has in a similar way produced the Annie ore shoot below the plane of the map, and the Josie dike has had the same effect upon the Le Roi and the

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Black Bear veins (see map III). In both these veins the solutions towards the west end seem to have been more or less confined to the space between the Josie dike and the partial barrier afforded by fault (D). Between (D and E) the ore bodies are smaller and less frequent. The principal channel for solutions has been between faults (E) and (I), where large masses of ore have formed, reaching widths of 100 feet up against fault (E). The same phenomena are repeated throughout the Centre Star ground, as exhibited by map II, which everywhere shows the tendency of such mechanical barriers to deflect or accumulate the solutions. In the Centre Star it will be noticed that the principal channel has been that portion of the vein between fault (K) and fault (Q). Fault (K), however, notwithstanding its large displacement, has for some reason been an imperfect barrier. In the lower levels heavy deposition has occurred on both sides of it, while on the second level, shown on the map, it has been mainly on the east side, and at this horizon is also accompanied by a deposition of ore along the plane of the fault. This is rather exceptional, and, in fact, is the most clearly marked case of deposition within fault planes. In the few other instances there is some doubt as to whether the material is not dragged ore or an original vein. As a rule, the faults do not appear to have been very accessible to the solutions.

The numerous instances of displacements by faults and dikes where the severed portions of the vein on each side are alike, prove that some of the dikes and some of the faulting occurred after the ore formation. If the dikes were studied in detail and classified they would probably be found to belong to two or more different periods, some of which were later than the deposits. As to faults, the facts observed accord fully with what is known of dynamic action during the long period while volcanic activity is expiring. Shocks and movements occur repeatedly at increasing intervals. Early fractures afford planes of weakness which would not only be kept open by the repeated movements but would be multiplied and extended by branches and interlacing fissures. Such action probably continued long after the ore de-

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position and also after the dike formation, since these are found to be cut by faults.

It is very noticeable that the later solutions introducing the gold and copper bearing minerals with quartz have, as a rule, followed the pyrrhotite deposition, and in this locality do not seem to have sought or found new permeable channels in the rock where these minerals might deposit by themselves. On the contrary, they seem to have been unmistakably restricted to the ground already impregnated with pyrrhotite, and the greatest enrichment has, as a rule, occurred where the previous pyrrhotite deposition was most extensive.

There seems no reason to believe that the pyrrhotite had chemically any more influence on the subsequent deposition than ordinary country rock would have. It may have been that the friable pyrrhotite ore presented such local weaknesses as to become especially shattered by the further repeated movements, and thus afforded the most permeable channels. What probably occurred, however, was that there was one continuous flow which gradually changed in chemical contents and conditions of deposition. The altered solutions at the time of the later deposition merely followed the channels of flow which were already established, possibly modified more or less by a refracture or brecciation of the pyrrhotite ore.

CONCLUSIONS.

The conclusions derived from a study of these deposits are as follows:

(1) The pyrrhotite was deposited from aqueous mineral solutions ascending through the more fractured and permeable portions of the shear zone fissures.

(2) The gold bearing chalcopyrite, pyrite and arsenopyrite with quartz were deposited later from the same flow rising within the same channels but restricted to those portions of the channels which still remained unfilled, or which were re-opened by further fracturing of the friable pyrrhotite ore.

(3) The main faults and some of the dikes existed before the formation of pyrrhotite began, or at least before its principal deposition.

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(4) Their intersections with the vein planes made barriers which more or less directed the flow, accumulated the solutions, and determined the position of the main ore bodies.

(5) After the ore formation more dikes appeared. Faulting was repeated intermittently, continuing probably up to recent times, and the early fractures were kept alive.

The writer is well aware that the origin of pyrrhotite is still in dispute by eminent authorities, but believes that a study of the Rossland deposits must remove any remaining uncertainties as to this question. All observations, from the occurrences of the pyrrhotite as mineral replacements, veinlets and films in the rock to the effect of dikes and fractures in massing its formation, point to deposition from mineral solutions. In these deposits at least, it is impossible to even consider "direct igneous origin" or "magmatic segregation," and no evidence has been found to suggest any difference between their origin and that of ore deposits of galena, pyrites or other minerals whose genesis is now established.

The evidence does show, however, that the conditions necessary for pyrrhotite deposition prevailed at an earlier time than those required for chalcopyrite, pyrite, arsenopyrite and quartz. It is well understood that during the period while heated waters are ascending in the vicinity of cooling eruptive masses the chemical contents of the solutions slowly change and so do the conditions of deposition. For the same flow to first yield pyrrhotite and then so alter as to produce the other minerals is no more exceptional than the well-known successive deposition in veins of the more common minerals. It may be that the only difference between their origin and that of pyrrhotite is that the latter requires exceptional depth, heat and pressure. The heat would be greatest during the earlier stages of circulation, and the great erosion noted by the Geological Survey indicates the prevalence of unusual depth and pressure at the time.

EFFECT OF STRUCTURE UPON MINING METHODS.

Map II illustrates the peculiar difficulties presented to exploration work within an ancient volcano. Every dike and every

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zone of fissures constituting a fault creates a gap or blank in the formation and to these are added the gaps due to vein displacement. Systematic cross cutting aided by diamond drilling is necessary on account of these displacements, vein-branching, the variations of vein thickness and the shifting of ore from one set of planes to another. If carelessly placed a cross cut or drill hole encounters so many of these blanks as to afford no information, or what is worse, indecisive results. It is therefore very difficult to make such work efficient, and it calls for every resource of care and skill.

In the War Eagle and Centre Star mines structure details are carefully kept up, and it is endeavored so far as possible to make cross cutting effective, to avoid work within belts of dike systems or belts of shattered ground, and to direct the principal explorations to the main channels of flow.

ACKNOWLEDGMENTS.

The structure details of the maps are by Mr. Carl R. Davis, E. M. Superintendent of the War Eagle and Centre Star mines, and Mr. Hugh Rose, A. B. Mining Engineer. The writer also desires to acknowledge the friendly assistance and courtesy extended to him by Mr. S. F. Parrish, Manager of the Le Roi Mining Co., Limited, and Mr. Wm. Thompson, Manager of the Rossland Kootenay Mining Co., Limited, and Mr. Paul S. Couldrey, Manager of the Le Roi No. 2 Mining Co., Limited, who have freely placed at his disposal all the data and information in their possession concerning the structure of these deposits.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

THE PRESIDENT—Mr. Brock is so well acquainted with the district referred to in the paper that we were fortunate to have him here to read it for Mr. Kirby, and we are all indebted to him for it. I understand that arrangements have been made to ship some of the Rossland ores to the smelters of the Boundary Creek,

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at a better smelting rate than can be obtained from the smelters close at hand, and this should help both districts. We would all like to hear from Mr. Brock in discussion of the paper.

MR. BROCK—Regarding the formation of these deposits, Mr. McConnell, who made the first examination, was inclined to regard these as having been formed in the manner outlined by Mr. Kirby. He reviewed various possibilities, particularly that of the pyrite and chalcopyrite having been formed by segregation of the basic materials around the edge of this gabbro mass, but concluded that the weight of evidence was in favor of aqueous deposition. In a paper which I read before this Institute in 1899 the conviction was expressed that they were undoubtedly formed by thermal solutions, and this theory was afterwards supported by the evidence of the well-known American authorities, Lindgren, Clarence King and Emmons in the Centre Star-Iron Mask lawsuit. It was suggested by some that on account of the marked resemblance between the Rossland and Sudbury ores the Rossland deposits should be re-examined in the light of their possible origin by magnetic differentiation in basic eruptive rocks. Our retort was that it would be well to re-examine the Sudbury deposits, keeping in view the possibility of their origin through aqueous concentration and deposition.

PROF. COLEMAN—I have been much interested in the paper as I have just been at work on the Sudbury region myself, and have picked up many a hand specimen which you could not distinguish from the ores of Rossland. I was especially interested in the final conclusion that the Rossland ores are apparently entirely of aqueous origin and not igneous, since I have come to the conclusion that the large marginal deposits at Sudbury are of igneous origin, though we have there also deposits of ore partly igneous and partly aqueous; but the great deposits, like that of the Creighton mine, are without doubt igneous. We find the rock often entirely enclosed in the ore, and also ore completely enclosed in the rock. The peculiar geological features, such as dikes, are largely absent in the Sudbury region, and it is possible that has a great deal to do with it. I should not be surprised if the fact that there has been a great deal of faulting and shatter-

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ing in connection with the dikes of different ages may account for some of the secondary re-arrangement, but I think it very possible that some of the pyrrhotite at least may have been part of the magma in the Sudbury region. We find the pyrrhotite existing in several different associations; part of it actually belonging to the rock, and other parts that have clearly been deposited in a secondary way. No platinum has yet been found at Rossland, however. We have the gold and the silver also, of course, in the Sudbury region, though in small amounts.

MR. BROCK—So far as I know no platinum has been found in the ore of the Rossland region, but I do not know that it has been specially sought for. It ought to be. It occurs in the Sudbury ore and in somewhat similar ores in Wyoming.

I think there is no question whatever about the aqueous origin of the pyrrhotite in the Rossland district and in the country immediately to the west. In fact, just to the west, in the Sophie mountain conglomerate, there are deposits formed by replacement of the materials of the conglomerate. I do think, however, that these ore deposits are closely connected with ore of the Alkali syenites found en masse immediately west or northwest of Rossland, and the numerous dikes in Rossland itself. There are some points of resemblance between the Rossland deposits and those of Boundary Creek spoken of in Mr. Keffer's paper. Some of the latter consist of masses of pyrrhotite bearing some chalcopyrite, although the majority have magnetite, the oxide of iron, in place of pyrrhotite, the sulphide of iron. These Boundary deposits possess the characters of deposits formed by pneumatolitic contact action. The gases, vapors or possibly solutions from the igneous magma have found their way into the neighboring country rocks near the contacts and there produced these ore bodies. As the solutions, etc., from the igneous magma wandered farther and farther into the country rock the veins would assume more and more the character of ordinary fissure veins. From this type of contact deposit to ordinary fissure vein there may be, therefore, all stages of transition. The Rossland deposits would seem to belong to this series, somewhat similar to the Boundary deposits, but lying much nearer the ordinary fissure vein type.

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MR. THOMPSON—Coming from Rossland as I do, I am exceedingly interested in this paper of Mr. Kirby's, and having five years' practical experience in these particular mines, I may say that I think Mr. Kirby is to be complimented on his paper this year; he certainly is to be complimented from the British Columbia miners' standpoint. We have for years been trying to get a map together showing the geology of the entire Red mountain district, where Mr. Kirby has been doing his work. Mr. Kirby is simply dealing with the mines of Red mountain alone, and it is quite true that on the ground covered by Mr. Kirby the pyrrhotite is very low. From the fact that five thousand tons of ore were shipped last year out of the Kootenay claims, the average value extracted being eleven dollars in gold, I have every reason to believe that the same conditions continue in a westerly direction until the Centre Star dike is found. At a point two thousand feet east of the right-hand side of the map exhibited is the Centre Star dike. West we have what is referred to as the Josie dike, so that between the Centre Star and the Josie dike we have veins lying approximately easterly and westerly. In an easterly direction from the Center Star dike we have several mines open. At the extreme east end of the deposits lies what is known as the Columbia Kootenay groups, that contain pyrrhotite ore which they are selling to the smelters, and for which they are being paid for the gold only. The average of last year's shipment for three months was five thousand tons, which amounted to something like eleven dollars per ton. Mr. Kirby is apparently not well acquainted with the district east of his own ground, while I have had the pleasure of being connected with nearly every mine in Rossland except the War Eagle and Centre Star, so that I am particularly familiar with the ground east and west of what is indicated on this map. You will observe on the map the main vein, there are at least four parallel veins crossing the mountain known as Red mountain, one of which is south of the main vein, one immediately north and another which evidently starts from the War Eagle vein, which is a spur vein running practically northwest from the main vein. At this point on the map we have a parallel vein mined by the Le Roi No. 2. The Le Roi No. 2 is a mine

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which has recently come to the front a great deal, and as a matter of fact it is the only mine in Rossland that has paid dividends for three successive years. The dividend this year is small but the earnings have been half a million dollars net from that mine during the past three years. You will notice here on the map the Josie dike, which plays such an important part in the ore deposit at Rossland. You can trace it through No. 1 across the mountain until it joins the Centre Star dike a mile and a half away. The Poor Man dike is a spur from the main Josie dike. Ore has been found west of this dike on the Josie and Annie ground, and that is the property they are now depending on to make money out of Le Roi No. 2. During the time I was manager of Le Rio No. 2 we paid three hundred thousand dollars in dividends, and these dividends came largely from ore bodies west of the Josie dike. The White Bear Company, which are operating west of the Josie dike have commenced to build a concentrator and to make shipments from ore discovered west of the Josie dike. Some very valuable ore bodies indeed have been discovered, and how far west they go is still to be determined.

I quite agree with Mr. Kirby in his conclusion, and I can only reiterate my opinion that so far as Rossland is concerned—and I think I may say the same for the whole of British Columbia—we are very deeply indebted to Mr. Kirby for the painstaking manner in which he has treated this subject in the paper which he has prepared. It was a very difficult undertaking for him, and I know Mr. Kirby gave a great deal of time to it, and a great deal more care than I would have cared to give myself. I hope that the government will take the hint, and note that these suggestions are really very valuable for the mining men of our particular district, and that they will be able to publish similar plans at the expense of the government, rather than at the expense of the individual, in the near future.

MR. BROCK—I am very glad that Mr. Thompson called attention to the fact that ore is being mined west of the Josie dike, as it corrects an impression which I did not intend to convey by my remarks in reading Mr. Kirby's paper. I did not mean to say that no ore had been found west of the Josie dike, as, of

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course, it has been known all along to occur there; what I meant was that the Le Roi vein, which is cut off by the dike, had as yet not been recognized as such on the west side of the Josie dike, nor was it known definitely in which direction it had been faulted.

DR. BARLOW—I have listened to the reading of Mr. Kirby's paper with a great deal of attention, especially to that portion of it relating to the origin of the pyrrhotite of the Rossland district in British Columbia. When the phenomenon known as magmatic differentiation was first brought forward to explain the manner of concentration of the deposits of the Sudbury district it was perhaps emphasized too strongly as in itself giving an adequate explanation of all the phenomena witnessed in regard to the mode of occurrence of these ore bodies. More recent and detailed examinations have shown that while the hypothesis of a segregation of these sulphides direct from the magma is in the main the true explanation of the formation of these ore bodies, other agencies, which are usually grouped together under the name of secondary action, have contributed rather largely to bring about their unusual dimensions. Their manner of formation is therefore much more complex than was at first supposed, but the simple doctrine of the direct igneous origin of these ore bodies and their intimate relationship in this respect to certain bands of norite and greenstone served an excellent purpose in directing and controlling all the earlier prospecting work.

The trend of some of the more recent examinations, however, seems to ignore the full significance of this intimate genetic connection, affirming that secondary causes or replacement are alone and directly responsible for the present position and dimensions of these deposits.

It is, however, certain that the sulphide material was introduced simultaneously and as an integral portion of the same magma along with the other minerals of which the norite or hypersthene-grabbro is composed. The pyrrhotite and charcopyrite are very intimately associated and often intergrown with one another and both are among the earliest of the constituents to crystallize from the original magma, sometimes even antedating the iron ore in which they are occasionally completely enclosed.

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They occur in very much the same way as the iron ore, embedded in, or in the immediate vicinity of, the various colored constituents and these two opaque consituents can only be distinguished from one another by their color in reflected light. These sulphides are frequently contained in portions of the norite, which are so fresh as to permit of the positive identification of such unstable compounds as hypersthene, enstatite, diallage and in one case (Little Stobie Mine) olivine, while the plagioclase is always more than normally fresh. Sometimes these sulphides are so abundant in these unaltered phases of the norite as to characterize this rock as a pyrrhotite-norite, specimens having been obtained which contain from 5 to 10 per cent. of these nickel-copper ores. These unusually rich nickel and copper sulphides are invariably associated with the norite and all of those of economic importance are situated either directly on the line of junction between this and the associated rocks or in its immediate neighborhood.

The question of the origin of these ore bodies is intimately connected with those processes, as yet but imperfectly understood, attending the various stages of the cooling and differentiation of huge bodies of igneous magma. As is doubtless well known to all of you, there is no such thing as dry fusion in nature and all igneous action is attended with or immediately followed by more or less pronounced vein or pneumatolytic action and certain rock masses and occurrences of mineral are representative of the various transitions between what may be termed hydro-igneous fusion to igneo-aqueous solution.

There can be little doubt of the abundant presence of such heated solutions which are capable of dissolving out and under certain conditions of redepositing these sulphides. Such agencies began their work before the whole magma had cooled, bearing their heavy burdens of sulphide material, most of which was obtained from the magma in the immediate vicinity, to occupy the various cavities and fissures as fast as these were formed. The whole of this action was practically completed before the intrusion of the later dikes of the olivine diabase, which are now regarded as the end products of the vulcanism to which the norite masses owe their eruption. In certain of the deposits, hydro-

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chemical agencies have been more active than in others, as at the Victoria Mine and some of the Copper Cliff mines, but in the case of the Creighton Mine, magmatic differentiation has, as Dr. Coleman remarks, been the main factor determining and favoring the development of this the largest nickel mine in the world.

The Rossland, B.C., ore bodies are likewise of igneous origin being associated with a monzonite, but the rock is very much more altered both as the result of dynamic and hydrochemical action. Secondary action is very much more pronounced and quartz and calcite, which are comparatively rare in the Sudbury rocks associated with the ore bodies, are both very abundantly represented in the Rossland district. In the case of the Rossland ore bodies, igneo-aqueous solution has played the most important part in their development.

After all, however, the origin of these ore deposits is largely a matter of theory and opinion, and strong arguments may be adduced to support the view either that they are the direct result of magmatic segregation or that the sulphides have been brought up from considerable depths to replace certain portions of the rock or fill up fissures and diorites caused by structural weaknesses. The real practical side of geological investigation consists in the outlining of these immense bodies of intrusive norite or gabbro with which the nickel and copper deposits of Sudbury are always associated, for although pyrrhotite and chalcopyrite are both found in connection with the older green schists and diorites, the deposits of these minerals in such cases are neither of large extent nor of unusual richness.

MR. INGALL—I am glad the point was brought out so strongly, that the difference between the gentlemen who are so fond of magmatic differentiation and the other theory is after all only a difference (or differentiation) of terms. These magma are a mixture of a lot of materials in various stages of separation from each other and the question of the actual temperature is not a matter of much practical importance, as when dealing with temperatures we may vary from something which we now think very cold to something we think very hot, and yet the real difference may be small. I remember when I was

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studying the Lake Superior silver district for the Survey in 1886, in one of the drifts in the Rabbit Mountain mine the vein was filled with a pulp thick enough to float a lot of crystals of the other minerals that formed in these veins, such as zinc blende and galena. The pulp was thick enough to hold them up, and it accounted in an interesting way for the fact that you find these perfectly formed crystals in such places. I should like to know whether that should be called magmatic differentiation or vein action. The degree of heat which constitutes the magma has never been settled.

PROF. MICKLE—With regard to the comparison between the Rossland and the Sudbury deposits I cannot see any resemblance at all. The first thing that must strike anyone is the remarkable difference in the form of the deposits, a plan of the Rossland ore bodies would have the form of a river, whereas the Sudbury deposits have the form of lakes, with or without irregular bays. Moreover, in Sudbury the plan of any particular level may differ entirely from that of the level above and below. Another difference that is striking is that the country rock in the Rossland district is weathered to a considerable distance back from the vein. In 1896 I took a systematic set of samples of rock from the Centre Star vein at Rossland, in a place where there was a crosscut that ran a hundred feet or so in each direction, starting close to the vein and going back twenty feet or more in each direction. The samples that I brought back were kindly examined by Dr. Coleman; without knowing where they were from he was able to notice the variation beginning with rock within a few inches of the vein that was so far decomposed that it was unrecognizable, back to the rock over 20 feet from the ore that was almost unweathered. The degree of weathering was in proportion to the distance from the vein, showing clearly that there was an action proceeding from the vein outwards, which, I think, could only be due to heated solutions. Moreover, in Rossland you see running across the ore veinlets filled with calcite, whereas you never see that in Sudbury. On the other hand in the latter place pieces of rock are seen imbedded in the ore, the sizes varying from the very smallest particles up to pieces presenting a face of several hundred square

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feet in area. Another respect in which they differ greatly, which affects their practical working and which, I think, points to their origin, is the distribution of their metallic contents—in Sudbury there is the greatest uniformity, relatively speaking, that is, taking the pyrrhotite only in any given deposit it will be found that the percentage of nickel and also platinum remains very nearly constant throughout the deposit, variations in the percentage in the ore are caused by inclusion of more or less rock. It is true that the amounts of copper vary considerably in different parts of the same deposit, as pointed out by Mr. David H. Browne in his paper on "Segregation in Ores and Mattes," there is a difference of 7 per cent. or more in the analyses of copper and nickel in different parts of a matte cooled in an ordinary matte pot. With regard to the distribution of the metals in the Sudbury deposits the ore resembles a low grade matte. In Rossland, on the other hand, the chief metal value—the gold—is most distressingly erratic, many large pyrrhotite deposits in the Rossland district contain no gold as far as worked, and others have gold only in places. This irregular distribution of the gold in itself appears to exclude the possibility of the igneous origin of the Rossland deposits.

Referring to the possibility of nickel in the Rossland pyrrhotites mentioned by Mr. Brock, in the early days of Rossland, when a great many more claims were being worked than at present, frequent analyses were made for nickel. I believe it was only found in any quantity worth considering in one place, viz., the Georgia claim, towards the Kootenay mountain. Any nickel occurring in ores from shipping mines would have, of course, long since been detected in the matte on smelting.

THE PRESIDENT—We have had a very interesting paper, and I think that Professor Brock is to be congratulated for reading it in such an able manner at such a short notice. I want to join Mr. Thompson in congratulating Mr. Kirby on the excellence of his paper, the care with which he has prepared the maps, and the valuable information which he has placed at our disposal. This paper will be a very important contribution to our transactions. I was very much interested not only in the paper, but in the discussion which followed, and which supplied a great deal of instructive

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material. As Mr. Kirby holds in the paper, and Professor Mickle has further pointed out, there is a very great difference between the veins of evidently aqueous deposition in Rossland as referred to in the paper, and the occurrences of similar ores at Sudbury, but nevertheless one may trace, as Dr. Barlow pointed out, the continuation of the igneous phenomena all through, from the magma itself, as at Sudbury, without hardly anything but the segregation of different mineral masses, to fumarolitic gas and aqueous depositions as at Rossland, that effects away form the magma itself, through the fissures of disturbed broken and shattered country rocks, in more or less close proximity to the parent igneous magma however. The one act of igneous or volcanic phenomena which is the final cause of the existence of these ores at both places, can be traced right through in a very instructive way, notwithstanding the very great difference between the physical nature of the deposits, and that is a very interesting thing, showing that when we come to regions like Sudbury we have reached pretty well to the bottom and final source. The great uniformity which Professor Mickle has pointed out of the mineral constituents in these Sudbury ore masses more directly from the magma is, therefore, only natural. There is also the other fact pointed out by Professor Coleman that there are no dikes at Sudbury, while Mr. Kirby's map of the Rossland region is full of them. That fact that there are no dikes at Sudbury is one of the great proofs that we have there the segregation at the commencement of the igneous phenomena. I would like to hear something from Mr. Thompson about the concentration of the low grade ores of that district, if he would care to deal with that phase of the question.

MR. THOMPSON—The concentration of low grade ores is rather a big subject. The methods adopted are the usual division to a suitable mesh and trying to get as clean a concentrate as possible. The Le Roi No. 2 sends the tailings to be treated by the Elmore process. Technically the plant has been a success, but commercially there is apparently room for improvement. The mill is a small one, the plant is experimental and I rather fancy that when larger units are put in, that probably the cost will be materially reduced. The general manager of the Con-

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centration Syndicate in a report to his London directors states that it will cost four dollars a ton after the ore is mined, with the present plant, but I think that this will be reduced to two dollars. Our friend, Mr. Kirby, is building a two hundred ton smelter at Trail to treat the War Eagle and Centre Star ore. He has not yet published his method of concentration so far as I can ascertain. The White Bear Mining Company, of Rossland, have ordered a one hundred ton Elmore plant for the treatment of its copper ores. If the cost is reduced sufficiently low I am quite satisfied that the plant will be a great success.

I have done a great deal of work on pyrrhotite ores with a view of cyaniding them rather than sending them to the smelters. At present we sell to the smelters. Whether we can go on with our smelter shipments or not depends on the question as to whether we can dispose of our ore at the present rate to the smelters. We can send the low grade ore at present to the smelter on favorable terms and make money out of it.

A year from now probably the members of this Institute will be able to get more valuable data as to the actual operation than they are in a position to get at the present time. At the present time everything is of an experimental nature, but I am quite satisfied that Mr. Kirby's process must have been quite satisfactory to him. He is a very conservative mine manager indeed, and I would hardly think that he would enter on a process of concentration unless he had fully concluded it would be successful. He is spending a great deal of money on one of the finest concentrating plants in the country, and it is only a matter of time with him when I believe he will make it a success. Of course, I may be considered optimistic, but I do think that the turn has come as far as the Rossland camp is concerned, and that many of the properties which in the east are now considered of no value, will become paying properties as these obstacles are soon to be removed which have prevented success in the past.

THE PRESIDENT—I wish to express the thanks of the Institute to Mr. Thompson, and I hope that his anticipations will be realized. I have no doubt that we can rely upon such men as Mr. Elmore, Mr. Kirby and others who are tackling this difficult problem, to attain a high measure of success.

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Journal of the Canadian Mining Institute, Vol. VII.

METHODS OF OBTAINING WATER SUPPLY, FOR SUGAR PLANTATIONS, IN THE HAWAIIAN ISLANDS.

By J. N. S. Williams, Puunene, Maui.

Toronto Meeting, March, 1904.

What is now known as the Territory of Hawaii, United States of America, consists of a group of islands lying in the Pacific ocean, 2,100 miles southwest from San Francisco, in longitude 155°-161° west and between the 18th and 22nd parallels of north latitude, just within the tropic of Cancer and in the path of the northerly trade winds.

The principal islands of the group are Kauai, Oahu, Molokai, Maui and Hawaii, also some small and unimportant islands near by.

Geologically this group of islands is peculiar and is supposed to be in connection with a long chain of islands stretching from northwest to southeast for some thousands of miles in the mid-Pacific ocean, the mountain tops of a submerged continent.

Each island in the group, with the exception of Kauai, consists of two mountain ranges of volcanic origin connected by an interval of comparatively flat and low land, these mountain ranges cross the path of the prevailing winds and form barriers to the clouds brought down, which condense and precipitate a heavy rainfall on the mountain slopes on the windward sides of the various islands.

This heavy precipitation, amounting to upwards of 400 inches per annum in places, has caused great erosion of the steep mountain slopes, which on the exposed side are seamed with tremendous chasms, some of them many hundreds of feet deep.

This process of erosion is still going on, and has had the practical effect of sweeping a great proportion of the surface soil of the windward coast down to the flats and into the sea.

For this reason the best and most continuous stretches of

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lands are on the flats connecting the mountain ranges, and on the leeward sides of the islands. Since the rainfall on this side, while extremely heavy at times, is intermittent and due to a wind which seldom occurs, the land is not much cut up by gulches or canons nor yet has it been denuded of surface soil to such an extent as prevails on the windward side, and is much more fertile and productive.

These lands are composed partly of volcanic mud ejected from volcanoes (now extinct) and partly of decomposed lava resulting from ancient volcanic action, and are covered by very scanty vegetation until water is brought out to them.

When the growing of sugar cane was first started on these islands, some forty or fifty years ago, the plantings were made on the windward side of the islands to take advantage of the rainfall, and it was not until some years after the inception of the industry that it become evident that the rainfall was not regular enough, excepting in some few places, to produce the best results in cane culture; and hence the first attempts at irrigation, accomplished by damming up streams and leading the water out by means of ditches to the head of the cultivated lands.

One successful ditch after another was put through and the sugar industry prospered greatly, giving incentive to works of colossal magnitude, consisting of miles of ditches and thousands of feet of inverted siphon pipes for carrying water across gulches which could not be bridged nor yet got around by flumes.

These siphon pipes are of sizes varying from 18 inches in diameter to 48 inches in diameter and are made of riveted wrought iron or steel plates of strength sufficient to carry static pressure due to heads of 500 feet and upwards.

These pipes are made in sections and riveted in place; the fall given to the siphon pipe is usually one foot in one hundred feet of pipe measured on the curve, that is the bottom of the entry ditch will be one foot in one hundred feet of pipe higher than the bottom of the delivery ditch.

The size of the pipe is calculated so that the velocity of the water through it shall not exceed from 3-7 feet per second.

This fall in the pipe is more than is necessary to pass the

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water at the given speed, but is allowed to compensate for the collection of mud, stones, etc., in the bottom of the pipe and also for any growth that may form on the interior.

These pipes are always fitted with manholes and waste valves at the lowest points for the purposes of inspection and cleaning and are kept painted with an asphalt composition on the outside.

It sometimes becomes necessary to make close calculations on the delivery of water in iron inverted siphon pipes, and the following useful formula, based on that of Trantwine, has been successfully used in such instances.

Formula for finding the *total* head in feet that must be given to a riveted steel or iron pipe of a given diameter, coated inside with asphaltum, to enable it to discharge a given required quantity: (Adapted from formula Art. 3, page 248, 1885 edition, Trantwine's Civil Engineers' Pocket Book):

Let H=total head or difference in level between the bottoms of entry and delivery ditches serving an inverted siphon pipe.

D=required discharge in cubic feet per second.

L=length of pipe in feet measured on the curve.

d=diameter of pipe in feet.

c=Constant=for asphalted riveted pipe 3496.

$$H = \frac{D^2 \times [L + (d \times 54)]}{c \times d \times (d^2 \times .7854)^2}$$

The constant c=3496, is deduced from the results of observations made by Mr. H. C. Perry, C.E., in charge of the ditches and pipelines on the sugar estate belonging to the Hawaiian Sugar Co., of Makaweli, Island of Kauai.

These pipelines are 40 inches diameter inside the small end of the courses of pipe, and deliver 55 cubic feet of water per second, measured over a weir situated in the delivery ditch.

In all siphon pipes used in this country the radius of curve is so great that the pipe can be taken as straight without appreciable error.

The formula gives results which compare closely with observed discharges in several pipelines varying from 20" to 48" diameter and from 500 to 2,500 feet in length.

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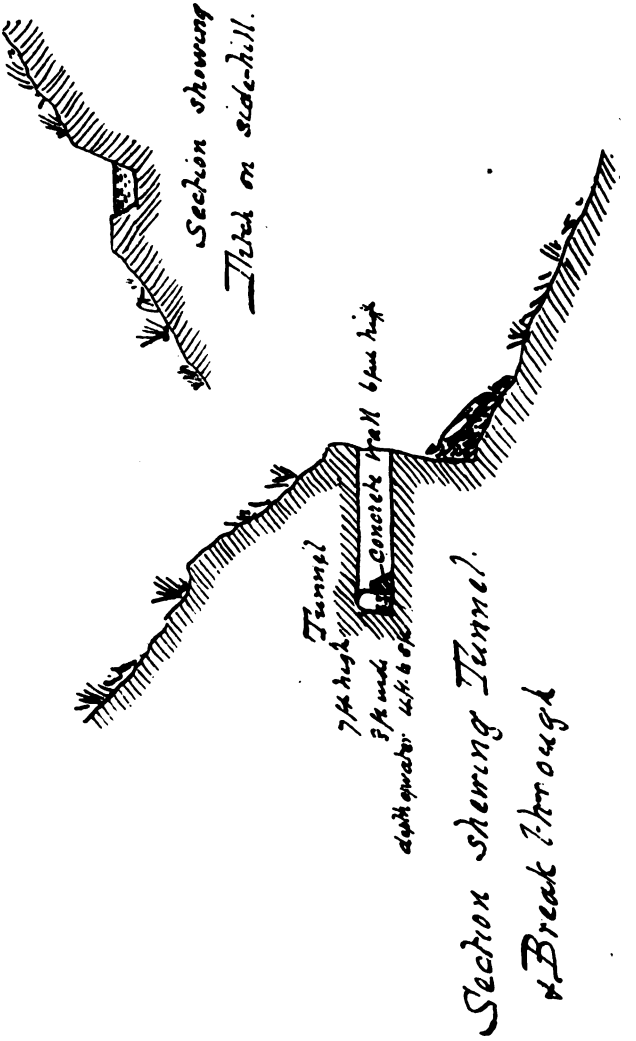

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No observed data are available for pipes longer than about 1,000 diameters.

Of late, tunnelling as a means of conveying water in a country very much cut up by gulches has been successfully adopted, particularly in districts where the canons are very deep and close together. The tunnels are driven on a grade and follow the general course of the canons, keeping some little distance back from the face of the bluffs; break-throughs are driven from the tunnels to the face of the bluff as a means of ventilation, for the discharge of rock and for the purpose of catching small streams which fall down the face of the cliffs, especially near the heads of the gulches—see sketch of cross section of tunnel herewith.

A special instance of this work is shown in the Olokele ditch just completed for the Hawaiian Sugar Company above mentioned; and in the Nahiku ditch for the Hawaiian Commercial & Sugar Company, of Maui, Hawaiian Islands, now under construction, both of which ditches, with all work connected therewith, are under the supervision of M. M. O'Shaughnessy, Esq., C.E.(1).

Where the tunnels pass through seamy rock the bottom and sides are lined with cement mortar, 1 part cement to 4 parts of sand, in ordinary rock the mud brought down by the water in freshets will, in a short time, tighten the tunnel bottom so that no leakage will occur.

The ditches are given a grade of 1 foot in 1,000, sometimes a little more, depending upon the scouring action of the water on the ditch bottoms.

As regards the construction of the ditches and flumes where used, the ordinary practice is followed, special care being taken at the entries to siphon pipes to fit substantial and large waste

(1) The author is informed by the Hon. H. P. Baldwin that this method of conveying water was first adopted in this country when the Hamakua Ditch Co.'s line on the Island of Maui was constructed some 25 years ago, since then this very bold scheme has been improved up to such an extent that in the above mentioned ditches no siphon pipes or flumes (which are liable to destruction by cloudbursts or violent rainstorms), have been used, and a large proportion of the entire ditch line is tunnel.

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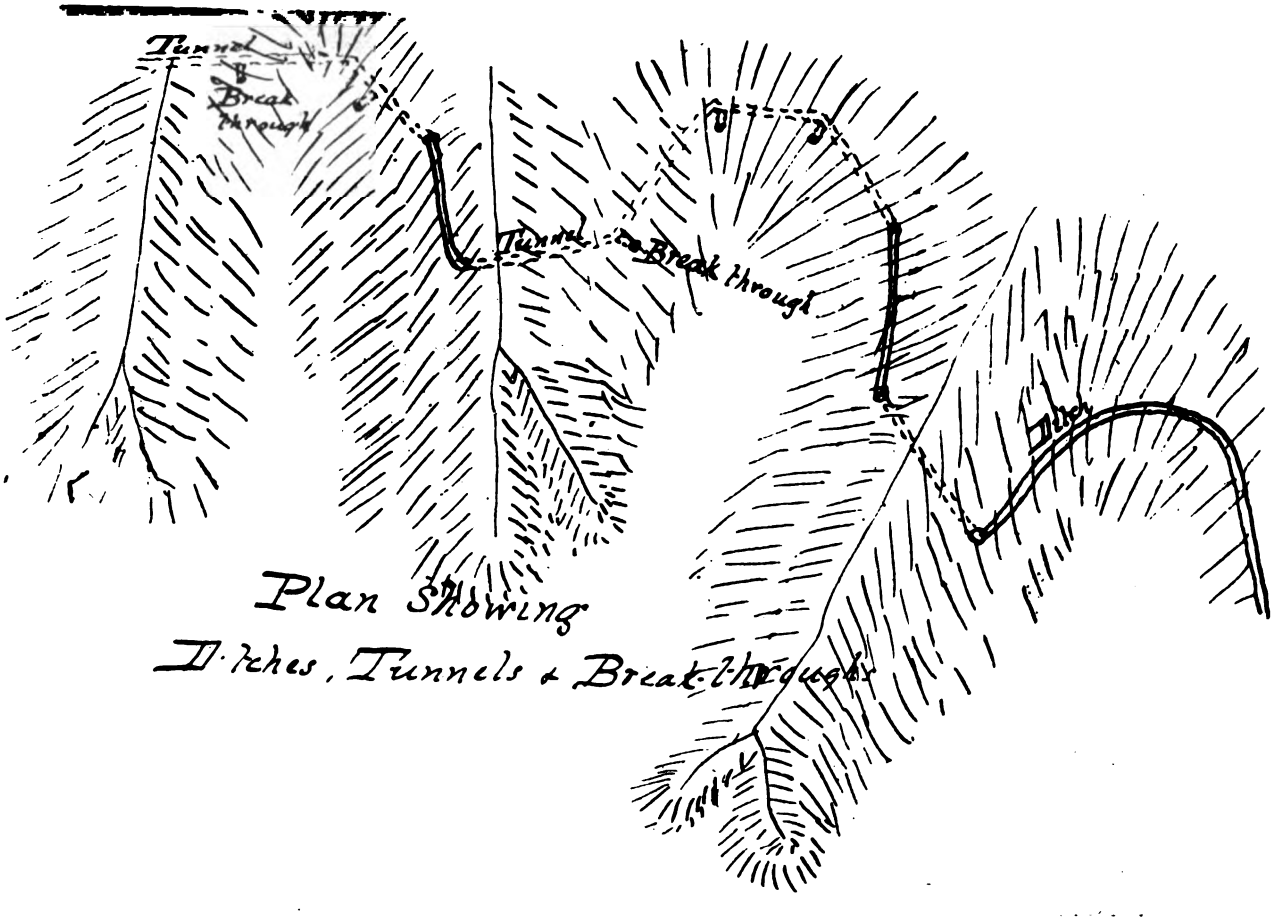

Plan Showing

Ditches, Tunnels & Break-throughs

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gates, so that in event of heavy local rain storms the excess of water shall escape away from the head works of the pipeline.

In general work on a sugar plantation that uses irrigation, the quantity of water required to properly irrigate 100 acres of land under cane cultivation is one million gallons per 24 hours, and as large plantations have from 7,000 to 12,000 acres of land in cane, from 70 to 120 millions of gallons of water per 24 hours is required.

Some plantations are situated in districts where no surface water is available, others again cannot obtain a sufficient supply from their ditches and catchment areas, so to supply their needs, sinking for water has been resorted to.

On the island of Oahu an underground reservoir of water which could be tapped by artesian wells was discovered some years ago; this water rises at this place some 30 feet above the level of the sea and is found at depths varying from 400 to 1,200 feet.

Pumping machinery of great capacity was put down and the underground supply drawn upon for use on the plantations situated within the artesian area.

At the present time the daily water pumped from artesian wells on the island of Oahu reaches about 300 millions of gallons, some of it lifted upwards of 500 feet in height.

This condition of an artesian supply does not appear to exist on any of the other islands in the group, and when pumping is resorted to, open wells or sumps are excavated, the underground supply resulting from rainfall on the mountainsides percolating through an upper broken stratum and retained by a lower stratum of impervious rock.

These sumps are excavated to about 20 feet below sea level, tunnels are then driven on the lower stratum directly inland, opening up the water bearing rocks, and the supply thus obtained is pumped from the sumps through very long pipe lines to the levels required on the cultivated areas.

To avoid the heavy expense of long pipelines, there are three instances of shaft-sinking at the upper levels of the cultivated lands down to sea level, and regular underground pumps of mining pattern installed, but these have proved so expensive in first

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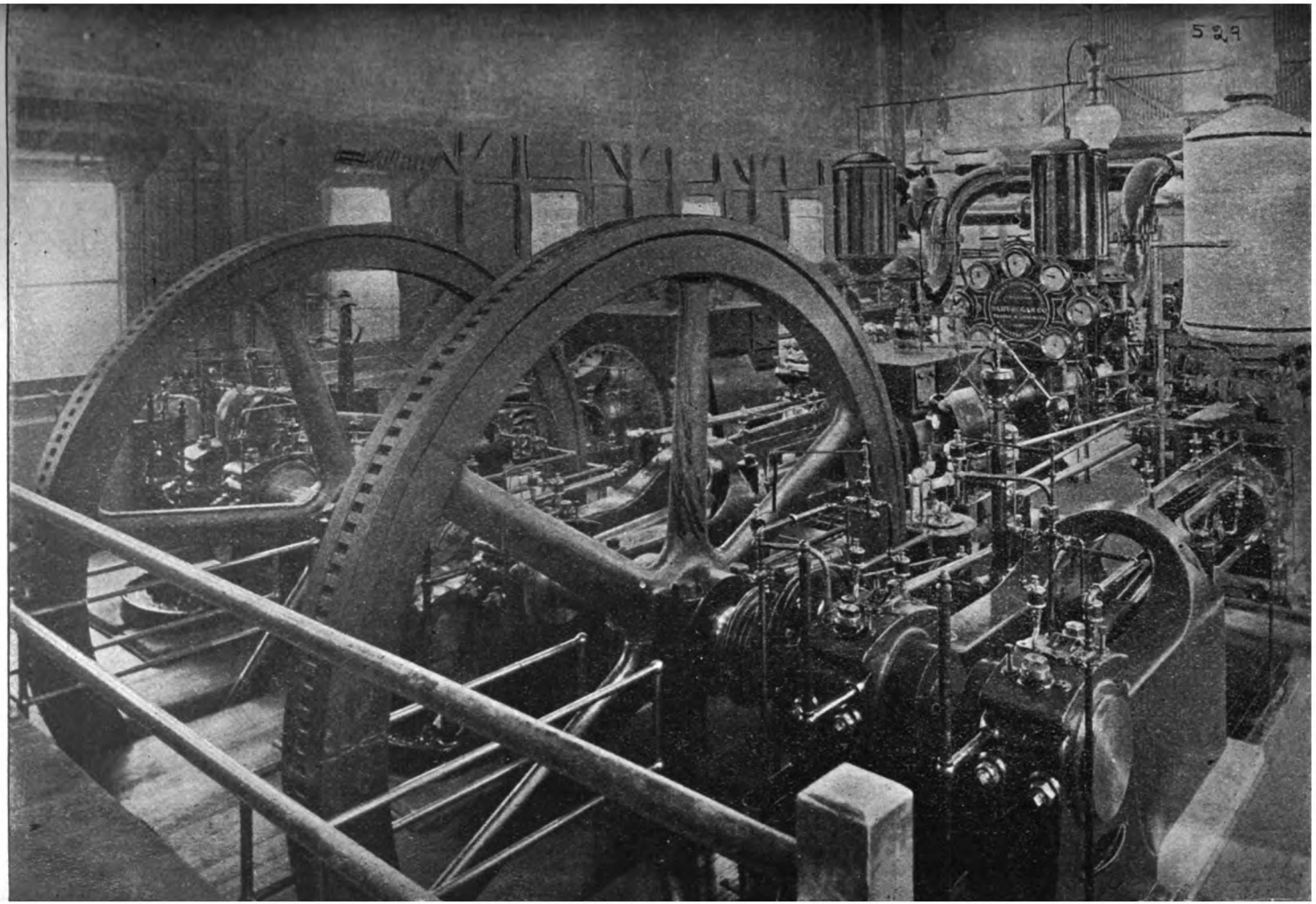

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cost and upkeep that there is no encouragement to repeat the experiment.

One of the largest stations of this kind is at Kihei, on the island of Maui, where the shaft is 300 feet deep and two pumping engines of a combined capacity of 17 million gallons of water per day lifted 400 feet high are situated in a very large chamber excavated in the rock; an abundant water supply is found at sea level, but the expenses of operation are very heavy in comparison to those of surface pumping stations delivering water through long pipelines.

The machinery installed in the various pumping stations is of the most modern and complete make obtainable at the present day, and as in no other part of the world are such mechanical irrigating plants in existence, a more than passing notice may be of interest.

The plantations that pump all or part of their irrigation supply are situated as follows:

Island of	Kauai,	3,	approx. delivery	24	hours, in	gallons....	75 millions
"	Oahu,	6,	"	"	"	...360	"
"	Maui,	5,	"	"	"	...150	"
"	Hawaii	2,	"	"	"	... 10	"
Total delivery per 24 hours, gallons, about.....						595	"

The average height to which this water is pumped is about 200 feet, and the total power developed to deliver this enormous quantity of water is over 20,000 horsepower.

The stations are divided into units of various capacities, situated at spots most convenient for obtaining the water. The largest units deliver from 10 to 12 million of gallons per 24 hours, and a station may have as many as four units; the majority have only one.

The pumps themselves can be divided into three classes: Impeller pumps, such as centrifugal or other types of rotary pumps; Multivalve pumps, such as the Worthington and others in which piston or plunger pumps draw and discharge water through large numbers of small valves set in suitable suction and discharge chambers, which valves open and close by the water pressure, and pumps having mechanically operated suction and discharge

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valves of which only one type, the "Reidler" Patent, constructed by the Allis Chalmers Company, of Chicago, has been operated in this country.

The pumping stations are fitted with all kinds of boilers, of which two makes stand first in point of numbers installed—Babcock and Wilcox water tube boiler and the Sederholm fire tube boiler—and there are all kinds of fuel and labor saving arrangements. Green economizers in the flues, arrangements for coal handling, automatic damper regulators, etc. And, as a result, exceedingly high efficiencies are obtained in ordinary work.

The engines driving the pumping machinery are almost all of the Corliss type two cylinder compound, three cylinder triple expansion, and four cylinder triple expansion of the very best make and finish and fitted with all modern appliances in the shape of condensers, feed water heaters, and in one instance the latest ideas in superheated steam have been applied.

The mechanical efficiencies obtained on the various systems of pumps are as follows:

Centrifugal pumps delivering to 50 feet head, from 45 to 55 per cent.; impeller or rotary pumps, from 60 to 75 per cent.; multivalve pumps, from 75 to 85 per cent., and mechanically operated valve pumps from 85 to 90 per cent.

In one mechanical efficiency test made by the author on a Reidler triple expansion pumping engine, delivering water at 375 feet above the level of the water in the sump, at the rate of 10 million gallons per 24 hours, and the water delivered by pump measured over a weir especially made for the purpose, the remarkable figure of 91.85 per cent. was obtained; that is, of the horsepower developed on the main engines 91.85 per cent. was expended in doing useful work on the water delivered.

This test was undertaken for the purpose of determining the slip or back lash of the water in a pump having mechanically operated suction and discharge valves, which in this instance was found to be ¼ of 1 per cent.

The necessity of high economy in pumping machinery in this country is seen when the cost of coal at from $7.00 to $9.00 per ton delivered into the furnace is considered.

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A large number of pumping stations are now operated with California crude oil as fuel, which is furnished to the various stations at about $1.50 per barrel of 42 gallons; at this price oil is about equal in value to coal at $6.00 per ton, but as oil leaves no residues nor yet soots up the tubes or economizers as coal does, the economy in labor by using oil instead of coal is very marked. In a large pumping plant formerly employing eight firemen and coal passers per day, and two water tenders, the eight men have been cut out entirely, the work of keeping steam with fuel oil being done, and done easily, by the two water tenders in addition to their other duties.

It, however, is clear that such an economy is obtainable only in large plants, as in small plants, operated by one man on a watch, no economy in labor is possible.

The burners used for crude oil are of various kinds and makes, but the results obtained by each are about the same, 6 pounds of ordinary crude oil of 18 Beaume (minus scale) being equal to 10 pounds of ordinary coal.

When the use of oil was first contemplated it was expected that the boilers would suffer from the intense heat generated in the furnaces, but this expectation was not justified, as all experience here goes to show that the life of a boiler will be just as long with oil as with coal for fuel, provided that the proper furnace arrangements are adopted.

By the courtesy of the Allis Chalmers Co. the writer is enabled to present plans showing a typical four cylinder triple expansion Reidler pumping engine and a Sederholm boiler fitted with automatic stokers, etc., also a photograph showing a three cylinder triple expansion pumping plant of ten million gallons capacity as erected and in working order on the Oahu Sugar Company and Hawaiian Commercial Company's plantations.

By the courtesy of the Hon. H. P. Baldwin, General Manager of the Hawaiian Commercial & Sugar Company, the writer is enabled to give the following figures for the cost of pumping water to different elevations by the following machinery:

Pump Plungers	11⅞"	diameter	x 42"	stroke.
Steam Cylinders H.P.	19"	"	x 42"	"
I. P.	33"	"	x 42"	"
L.P.	50"	"	x 42"	"

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The whole forming a Reidler triple expansion pumping plant.

Sederholm boilers, Greens economizer, California crude oil for fuel, steam pressure 180" above atmospheric pressure.

Revolutions of Engine per minute, 54.
Delivery in 24 hours at this speed, 9 million gallons.

Elevation of Delivery.	Cost per Million Gallons.
100 feet.	$ 7.85
200 "	11.57
225 "	12.50
250 "	13.44
300 "	15.30
350 "	17.17

which figures include superintendence, labor, fuel, supplies and repairs during one year, which contained 240 pumping days. The figures would be considerably modified if continuous pumping were employed, but as occasional rain storms occur, the pumps are only operated when required.

The economy of such a pumping plant is high; one horsepower being produced for the consumption of 1.12 lbs. of oil per hour, which, at the rating of 6 lbs. of oil being equal to 10 lbs. of coal in ordinary work, is equivalent to 1.87 lbs. of ordinary coal horsepower per hour.

As a rule pumping is considered to cost 50 per cent. more than ditching, but since a ditch depends on rainfall for its supply, there is an element of uncertainty about it. Pumping, on the other hand, is very sure, since the underground supply of water is practically inexhaustible, and even during severe droughts, when the ditches are nearly empty, the pumps are always able to furnish water.

The most conservative practice in irrigation works for sugar plantations, where possible, is to have both systems, so that whichever way the barometer goes water is available for the crops in the ground.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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Journal of the Canadian Mining Institute, Vol. VII.

NOTES ON THE CONSTRUCTION OF MINE BULKHEADS.

By William Thompson, A.M., Can. Soc. C. E., Rossland, B.C.

Toronto Meeting, March, 1904.

The writer was recently called upon to design and erect a number of mine bulkheads which required to be absolutely free from danger of collapse and fracture and possibilities of leakage. After consideration of the many classes of material available for this purpose, and various designs of construction, the following general design was decided upon and followed:

Materials:

Materials chosen for the erection of the bulkheads were hard burned, repressed brick, manufactured from clay found at Clayton, in the state of Washington, U.S.A., Portland cement imported directly through Vancouver agents from White Brothers, of London, England, and clean river sand found locally. Before being used samples of all materials were tested in the laboratories of Dr. J. T. Donald and McGill University, Montreal, Quebec.

Design of Bulkheads:

In each case the pressure exerted from the head of water to be retained was in one direction. Bulkheads were, therefore, erected in the form of an arch set against footings cut into the solid rock, footings also being cut into the roof and floor of the workings to remove loose or fractured material and make perfect seal against leakage at point of contact between brick work and walls of drift. The first arch was reinforced by a second arch of similar design and the space between the intrados and extrados of the two arches filled with strong cement concrete. The extrados of the final arch was also sealed by strong cement concrete faced with two-inch cedar plank. The strongest and most perfectly shaped brick were chosen for the construction of the main arches, and the mortar used consisted of two parts sand to one cement, freshly mixed as required.

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Strength of Materials:

BRICK—Transverse Test:

Distance between centres of support in each case 6".

Specimens tested on flat:

Breaking load at centre in lbs., arch brick..... 6,500 lbs.
Breaking load at centre in lbs., face brick..... 3,900 lbs.

Compression Test:

Load in lbs. per sq. in. at initial failure, arch brick 6,600 lbs.
Load in lbs. per sq. in. at initial failure, face brick 2,117 lbs.
Maximum load in lbs. per sq. in., arch brick.... 8,320 lbs.
Maximum load in lbs. per sq. in., face brick.... 3,242 lbs.

Cement:

Tensile strength in lbs. per square inch:
Neat cement 20% water, at end of 60 days, 699 lbs.
One cement and one standard quartz sand, same period, 540 lbs.
One cement and one sand, used same period, 498 lbs.

Plan of Bulkheads:

Diagram No. 1 shows vertical section, and Diagram No. 2 plan of bulkhead erected to withstand pressure due to 475 feet of water.

DIAGRAM NO. 1:

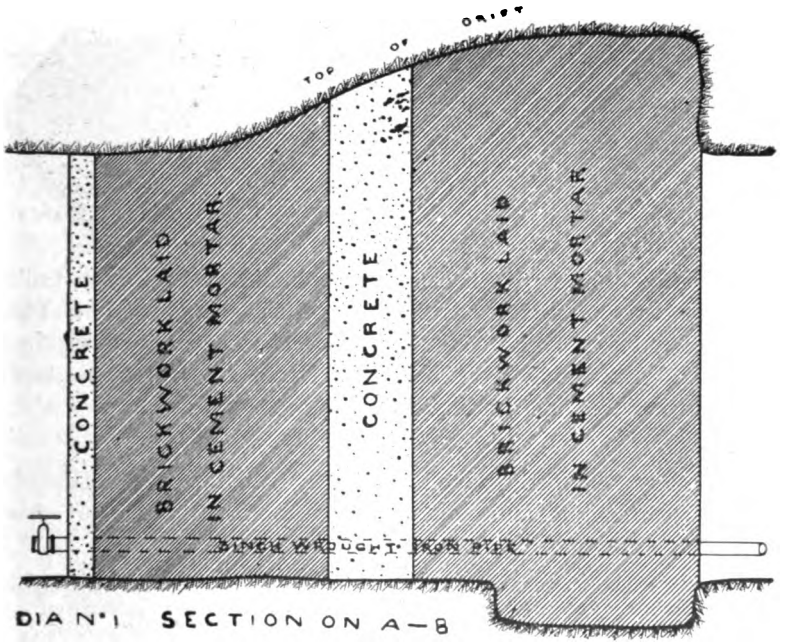

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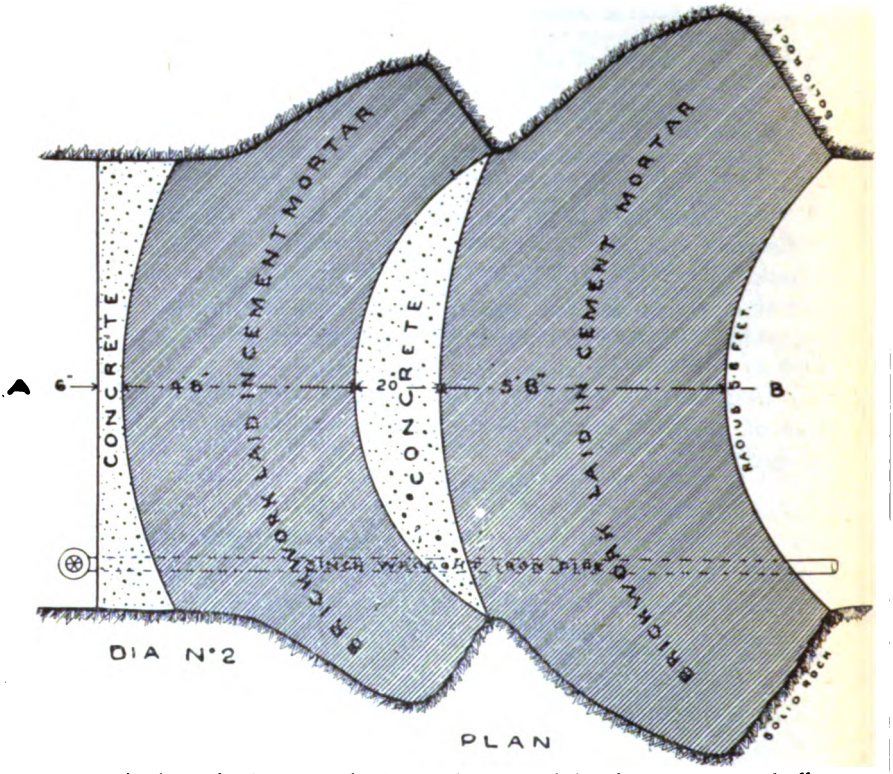
DIAGRAM NO. 2:



A three-inch wrought iron pipe was laid through each bulkhead to carry off water accumulating during construction. This pipe being sealed when water was allowed to accumulate against the face. Bulkheads were maintained free from pressure until material had become thoroughly set.

Results:

Results obtained proved eminently satisfactory, bulkheads proving watertight, and owing to large factor of safety are free from any danger of collapse or fracture.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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DISCUSSION.

At the conclusion of his paper Mr. Thompson said:

I wish to cite the conditions under which the bulkheads had to be erected. I may say that the Rossland mines of which I am manager, connect with the workings of the Centre Star, which in turn connect with the workings of Le Roi, and it is quite probable that at some future time the Le Roi will be connected with the White Bear. The shaft of the Le Roi mine is now down about one thousand three hundred and sixty feet, and the shaft of the Centre Star about twelve hundred feet, which, taking into account the elevation of the mouth of these shafts, really brings the two shafts of an equal depth. It was found necessary to close down part of the workings of the Nickel Plate Mine and it then filled with water. Naturally our neighbors complained that we should not allow this water to accumulate in our mine, and allow it to flow into their mine. Therefore, it became necessary to build bulkheads. Some of these were subject to a strain of eight hundred feet of water, and having probably from five hundred to seven hundred and fifty men working underneath this water, it was very essential that the bulkheads should be built safely, and that there should be no possibility of leaks occurring which would necessitate damages being paid on our part, and which would be a serious matter indeed should the bulkhead collapse in any shape or form. The paper which I have read simply gives notes on the methods adopted to construct these bulkheads, which in my opinion are absolutely safe and have so far proven to be free from leak.

My greatest difficulty was to get the brick work tight to the rock of the drift so as to stand the heavy pressure. I may say that they were the strongest bricks I have ever seen. They were made very carefully, very well pressed, and then they were carefully burned, the clay being of an exceptionally good quality.

The cost, I may say, varies with the conditions. The cost of each bulkhead was approximately twelve hundred dollars, but we had to pay the bricklayers six to seven dollars and fifty cents for eight-hour shifts, and they did not exert themselves very much at that. Bricklayers were very hard to get, and I am quite satis-

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fied that from the conditions which prevail in Ontario the cost would be very much less. The brick cost thirty dollars with us, and the cement five dollars and fifty cents, so that both the materials and labor were high. I found that by using machine drills to cut ditches I had to resort to light charges, and so all the cuttings had to be done by hand. The bulkheads each cost twelve hundreds dollars and contain about twenty-five thousand bricks.

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Journal of the Canadian Mining Institute, Vol. VII.

POPLAR CREEK AND OTHER CAMPS OF THE LARDEAU DISTRICT.**

By Prof. R. W. Brock, Kingston, Ont.

Toronto Meeting, March, 1904.

The term Lardeau district will be used to embrace the strip of country extending southeastwards from the north east arm of Upper Arrow Lake and Fish River to the head of Kootenay Lake. A low valley extends through the centre of the district from the North East Arm to the Duncan River and Kootenay Lake, occupied for the greater part of its length by Trout Lake and the Lardeau River.

The district lies in one of the most rugged and picturesque portions of the Selkirk Mountains. Huge, massive mountains culminating in lofty craggy peaks are separated by narrow steep-walled valleys. The altitude of the mountains gradually increases going northward and eastward from the head of Upper Arrow Lake, from about 8,000 feet to perhaps 11,000, north and east of the Duncan River.

The Lardeau district can be entered from either Upper Arrow Lake or from Kootenay Lake. A steamer, connecting with the Arrowhead branch of the C.P.R. and the Arrow Lake steamer, runs to Comaplix and Beaton, at the head of the North East Arm. From these points wagon roads with stage lines run to Camborne, the centre of Fish River Camp. From Beaton the wagon road extends to Trout Lake City at the head of Trout Lake; from there a wagon road runs up Lardeau Creek to Ferguson and Ten Mile. Stage lines operate between Beaton, Trout Lake and Ferguson. A steamer connects Trout Lake City with Gerard at the foot of the lake. From here a branch line of the C.P.R. runs to Lardo, at the head of Kootenay Lake, whenever steamers run daily

** Read by permission of the Acting Director of the Geological Survey of Canada.—A fuller description of the district appears in the Summary Report of the Geological Survey of Canada for the year 1903.

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to Kaslo and Nelson. From these main lines of travel trails run up the principal creeks.

DEVELOPMENT OF THE DISTRICT.

The Lardeau district has been recognized as a mineral district for some time. Claims were located near Comaplix, on the Northeast Arm, as far back as 1888, and the Lardeau itself was prospected and staked ten years ago. From that time on prospecting has continued and the development and opening up of the district has gone slowly forward. But the district has not received as careful attention from either prospectors or mining men as its mineral indications would warrant. Several causes have contributed to this, the rugged nature of the country, its isolation and consequent distance from smelters have made it impossible to handle anything but the richest ores; prospectors decided that it was a silver-lead district only, and searched for nothing else. The depression in the silver-lead markets had a strong retarding influence on the young, undeveloped district. Many claim owners, in view of the high assays obtainable, and regardless of the great cost of mining and transporting the ore, held their claims at prices that were prohibitive in an undeveloped district where so many natural difficulties had to be overcome. However, the district is now easily accessible, and in many parts well opened up with roads and trails, which greatly facilitate prospecting. A number of claims are now developed and provided with facilities for handling, and in some cases treating their ores on the spot. With the successful operation of these, and the recent discoveries of rich gold ores on Poplar Creek this summer, it is to be anticipated that the district will soon receive more attention from both prospectors and mining men.

GEOLOGY OF THE DISTRICT.

In the nature of the rocks and the character of the ores, the Lardeau has many points of resemblance to the Slocan district. The statement sometimes made that there are none but sedimentary rocks in the Lardeau is far from being correct, although sedimentary rocks are probably more widespread.

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The latter consist of argillites, limestones and sandstones and conglomerates, altered by the mountain building process to phyllites, generally carbonaceous, sericite and chlorite schists, calc-schists, crystalline limestones and quartzites, or squeezed quartz porphyries. At one or two points volcanic tuff may be recognized and some of the schists may represent altered ash rocks.

In these sedimentary rocks, often interbanded but sometimes cutting across them at low angles, are dikes and masses of

Weathering of rocks, showing how jointing and stratification control the topographical forms produced by erosion.

diorite or gabbro porphyrites and possibly augite porphyrites, but these rocks are usually so altered by dynamumetamorphism that their original nature cannot be determined with precision. They are now usually in the form of green chloritic schists. Intrusive in these preceding rocks, though often interbanded with them, are small dikes of a rock which is now generally a rusty weathering schist consisting of various secondary minerals, of

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which serpentine, quartz, sericite and carbonates are the most prevalent. In an extreme form of alteration it consists of sericite, carbonates and some limonite; the carbonates may be present in such quantity that the rock effervesces violently with acid, and might thus be mistaken for a limestone. In less altered samples, and in its geological relationship it is clearly seen to be an intrusive rock; microscopic examination points to its having been in all probability a diabase originally, and in this paper it will be referred to as a diabase or a diabase-schist. Along the southwestern border of the district a white acid granite, intrusive in all the other rocks, occurs. In places it is a normal granite, in others a hornblende granite.

Aplite and pegmatite dikes are numerous at many points, even at some distance from the granite outcrops. The granite is very fresh in appearance, and has escaped most of the metamorphism that the older rocks have suffered from.

GEOLOGICAL AGE OF THE ROCKS.

The geological age of the rocks could not be definitely determined. The oldest rocks are the sedimentaries. Fossils were found at two points in them but were useless for determining the horizon. They are almost certainly Palaeozoic and perhaps carboniferous. No doubt they correspond with the Slocan series of West Kootenay. The greenstones or chloritic schists are later than these. The diabase schist is newer than the chlorite schists. The granite is very similar to the Valhalla granite of the West Kootenay sheet, and is probably of comparatively recent age, possibly Cretaceous or Tertiary.

STRUCTURE OF THE DISTRICT.

Since there are few well marked horizons, and since the eruptive rocks interfered with the regular sequence of the stratified rocks, it is difficult to make out the structure of the district. Faulting adds to the complexity of the problem. Throughout the greater part of the district the rocks are tightly folded along an

(1). The bearings in this paper are magnetic. The local variation of the compass is about 25° east. That is, for true astronomical bearings add 25° to the reading of the instrument.

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Gainer Creek, lime dike in the background.

Lime Dike, between Gainer and Porcupine Creeks.

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axis of approximately 280 degrees(1). At many points the folds are compound, the anticline consisting of numerous small anticlines or synclines (anticlinomium).

The axis of the folds are pitching northward in the northern part of the district.

Trout Lake valley appears to be on the southwesterly limit of a large, slightly overturned anticline. A conglomerate occurs here which might be used as a key horizon for working out the

Pool Mountain, east of Beatrice Mine.

structure, but it was not noticed elsewhere. At the head of Gainer Creek the structure is revealed by the so-called "Lime Dike," The first (most southwesterly dike) is formed by the outcropping of a limestone band in the southwest limit of an oppressed anticline. A subordinate anticline or syncline with the arch eroded lies immediately north of this, the basin of the syncline still remaining, forms the second dike. A few miles to the southeast, on the ridge east of Cariboo Creek, the miner fold is a syncline. A second

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structural feature of the great regularity and importance is the jointing of the rocks at right angles to the strike. This, with the bedding planes, cuts the rocks into rectangular blocks. These two structural features, the northwesterly—southeasterly strike and high dip and the northeasterly—southwesterly jointing planes determine the chief topographical directions to the valleys and ranges conforming to these directions.

THE ORE DEPOSITS.

Three more or less clearly defined zones of mineralization may be recognized: First, a southwestern belt on the slope to the southwest of the main valley running through the district, bounded on the southwest by the granite mass, but with undefined northeastern border; second, a somewhat sharply defined central belt commencing at Fish River and extending southeastward across Pool Creek, Beatrice and up Northern Mountain across Lardeau Creek and along Silver Cup Mountain, crossing Lardeau River about Tenderfoot Creek, and running down the southwest bank of the river across Poplar Creek, and, thirdly, the lime dike belt, extending from McDougal Creek in Fish River across Boyd, Lexington Creek and the head of Pool Creek, and along the divide between the Lardeau and Duncan River basins.

FISH RIVER CAMP.

This camp, situated in the lower part of Fish River, was located as a silver-lead camp, but at present the principal development is confined to gold leads. Camborne, the centre of this district, is situated on the central mineral belt. A somewhat narrow band of phyllite cut by the diabase schist, lies here between rather broad bands of the chlorite schists. The green chlorite schists, so far as observed, are without mineralization, but the lime dike belt to the north carries silver ores, mostly galena blende tetrahedrite and a little pyrite and chalcopyrite. Some of these deposits are high grade, but some, as the Alma, on Pool Creek, are largely low grade.

Claims were located on the central belt for silver-lead. In 1900 an inexperienced prospector discovered a quartz vein with some specks of galena on the lower slope of Lexington Mountain,

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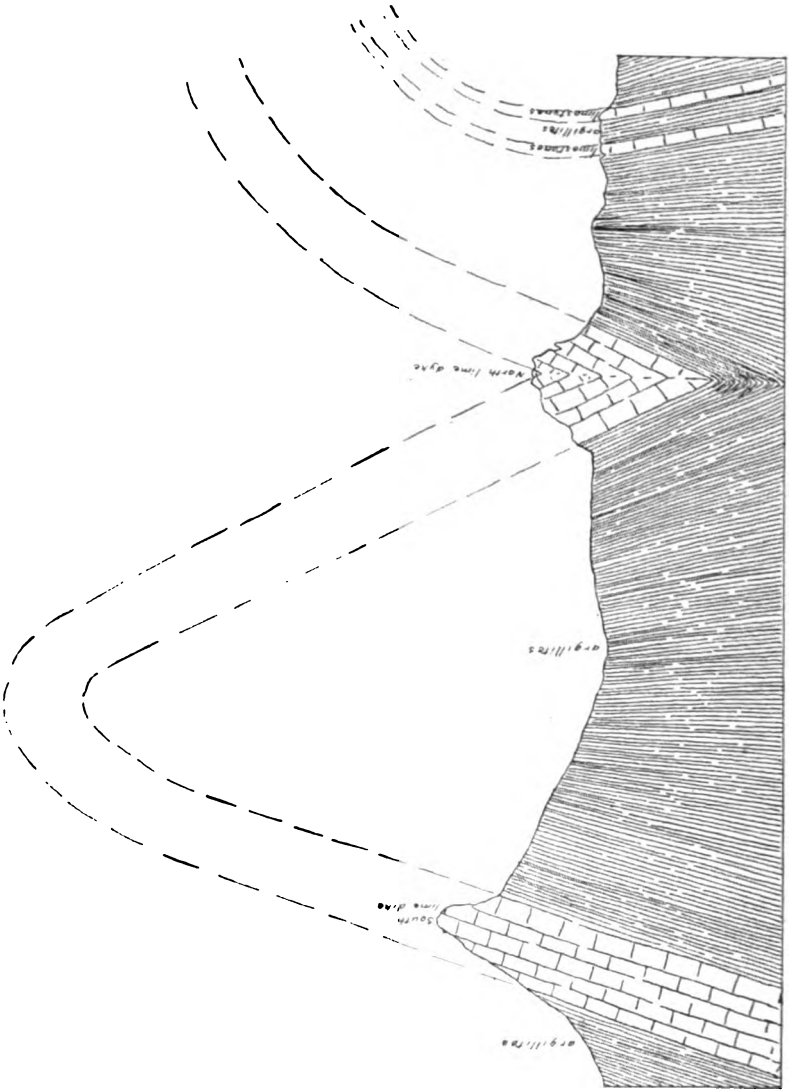

Section showing folding and lime dikes on ridge south-east of Porcupine Creek.

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between Pool Creek and Fish River, which he located for silver-lead. Assays revealed a high gold content, and a number of gold claims were staked in this lead. The Imperial Development Syndicate, of Nelson, was formed to develop some of these claims under the management of Mr. A. H. Gracie.

After some development the Eva group was sold to the Calumet & British Columbia Gold Mines, Ltd., who have erected a 10-stamp mill and tram, and are now operating the Eva. The main lead has now been traced from Fish River southeastward for about a mile, and it probably extends to Pool Creek.

EVA GROUP.

The lead consists of two veins lying in and along two fault planes, which dip about 80° away from one another, connected by numerous cross veins and stringers. The direction of the lead is 120°, cutting the formation at a low angle. The country rock is a spotted phyllite consisting of sericite, calcite, quartz and probably feldspar and iron ore. It is cut by the diabase schist, here highly altered. The vein matter is quartz, calcite, feldspar, siderite and sericite, carrying some sulphides and free gold. The sulphides are principally pyrite, sometimes well crystallized, a little galena blende. Gouge along the faults has confined the vein material between these lines. In places the vein consists purely of vein matter, sometimes banded and with divisional planes parallel to the walls or to the stratification of the country rock. Sometimes the vein holds intrusions of country rock more or less replaced by veinstone; in other places the quartz is deposited in thin bands along the lines of stratification. The rock between the two main veins is often impregnated with vein material, besides being traversed by numerous cross veins. Such rock may assay $2.50 per ton. The quartz will pan almost everywhere, but the values are not evenly distributed.

Gold visible to the naked eye occurs in solid quartz, in seams in the quartz and along the selvage of the veins, generally in small scales or nuggets, which are sometimes dusted through the rock in particles as fine as needle points. It is often concentrated along the walls or around inclusions in the vein.

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As such points are often carbonaceous, the carbon may have been responsible for the enrichment (acting as a precipitant). The veins are usually higher grade when a cross vein joins the main vein. Zinc blende is said to be a good indicator of values. Pyrite is sometimes very rich. Galena may or may not carry gold values.

About 2,200 feet of development work has been done. A tramway raises the ore over a shoulder of the hill and conveys it 4,200 feet to the stamp mill built on the north side of Pool Creek above Camborne. The mill is a well constructed and well equipped 10-stamp plant, resting in a graded rock foundation. It is operated by water drawn by a flume from Pool Creek under a 400 foot head.

The clean up for December is said to have yielded a gold brick valued at $10,400, with about $600.00 worth of concentrates.

OYSTER CRITERION GROUP.

The rocks and ore on these claims resemble those of the Eva. The replacement of the country rock by vein material is very plainly seen.

The veinstone, consisting of quartz, striated or unstriated feldspars, carbonates and sulphides form stringers between the laminas of the phyllite. This vein material then eats into the rock, forming cloud-like masses, and the grains of the rock gradually lose their identity; finally they are completely changed to vein matter, sometimes with nuclei of the phyllite remaining. Thus all stages may be met with in the lead between solid veinstone and reticulating veinlets between blocks of country rock. The gold is often concentrated round these inclusions so that the mottled portions of the veins are often rich.

Three main veins are recognized: the Eva No. 2 gold vein, the Criterion vein and the galena vein. The diagram will show the relationship between these veins.

The Eva and Criterion veins, if they maintain their direction, should intersect on the Oyster ground. Reasoning from analogy, when they intersect, increased values may be found, and probably cross veins and other veins be met with. The galena vein, besides

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the lead sulphide, carries blende and iron or copper pyrite rather heavily developed in a quartz gangue. The veins vary in width from a few inches to a number of feet.

On the Beatrice, near the head of Mohawk Creek, a quartz vein with some sericite and calcite occurs in a highly carbonaceous phyllite. Blende is, perhaps, the commonest sulphide. It is veined by tetrahedrite. Galena also is found of later formation than the tetrahedrite. Pyrite and chalcopyrite occur intimately mixed, veining the zinc blende, and apparently formed later than the tetrahedrite.

FERGUSON CAMP.

Ferguson is the mining centre of Lardeau Creek. The central mineral belt from Camborne crosses from the Beatrice to the Lardeau slope, continuing over Great Northern Mountain, the spur of Ferguson Mountain between the forks of Lardeau Creek and up the slope of Silver Cup Mountain to its summit. On this belt a number of claims have been located. The most important mining operations yet carried on in the Lardeau district are those in connection with the Nettie L and Silver Cup mines situated in this camp. On the Trium considerable work has also been done.

A considerable section of the lime dike belt is also tributary to Ferguson, but on account of difficulties of transportation little work is at present in progress on the most promising claims in this belt.

NETTIE L.

The Nettie L is situated on a spur of Ferguson Mountain, about 5,100 feet above sea, or 2,100 feet above the towns.

The country rocks are carbonaceous phyllites or slate. Some quartzitic rocks already referred to occur in the neighborhood together with dikes of the diabase schist. The average strike of the rocks is about 280°, but varies somewhat on account of folding. A synclinal fold seems to be here developed, whose symmetry is disturbed by faulting. The dip and strike at any point will, therefore, depend on its position in the fold.

About 6,000 feet of work have been done in two claims open-

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ing up three leads, known as the main, the cross lead and the big quartz vein.

These veins are for the most part independent of the strike of the rocks. On the Ajax claim, adjoining the Nettie L to the east, and belonging to the same company, the lead opened up appears to follow the bedding of the rocks in seams and reticulating veinlets. The rocks here are folded into a canoe shaped syncline. The strike changes from easterly with a northerly dip, to northerly with a westerly dip. Successive portions of the ore following the beds turn northward from their original course.

The ore consists of quartz heavily mineralized with tetrahedrite, galena blende and some copper and iron pyrites. When weathered, wire silver is occasionally found. Zinc blende has been the first of the sulphides to be formed. It is replaced and veined by tetrahedrite. Copper pyrite veins the latter, galena is newer than copper pyrites. Some quartz and calcite have been developed after the sulphides. Sericite is found sparingly in the quartz gangue.

The vein matter may form a solid mass or may occur as numerous reticulating veins or stringers in the rock. Replacement of the country rock by vein material has often occurred. Beside the silver and lead values some gold is obtained from this ore.

An aerial tramway is being constructed from the mine to a silver mill in course of construction at Five Mile.

The Silver Cup mine is also to the south of Lardeau Creek, near the crest of Silver Cup Mountain. About 5,000 feet of work has been done on the property, mostly in the Silver Cup and Sunshine claims. The country rocks consist of carbonaceous slates or phyllites, with the usual strike and dip, and dikes of the altered rusty weathering diabase schist, which while almost parallel to the slates, sometimes cuts them.

Two main leads occur, running almost parallel to the formation, one of these is "blind," that is, it is not found on the surface. Connecting these parallel leads are numerous cross veins, one of which makes a large body of ore. The veins present the same characteristics as the Nettie L vein. The ore is localized in chutes of lenticular form, some of which are of large size, one slope

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being 275 feet long. The chutes occur where cross fissures meet the leads. Sometimes some of the numerous slips form apparent walls to the lead, but vein matter is usually found beyond such walls. So far the ore is confined to the slate band between two parallel dikes of the diabase, although the latter rock has been mineralized with pyrite.

The character of the ore is similar to that of the Nettie L: argentiferous tetrahedrite has been taken out in blocks up to 18 inches in diameter. Some of the richest tetrahedrite yet found has been obtained in considerable quantities in the deepest workings, 600 feet below the highest, indicating that the values are not the result of mere superficial alteration and enrichment of the vein. The first-grade ore carries $12 per ton in gold in addition to its silver and lead values.

An aerial tramway connects the mine with the wagon road on Lardeau Creek. A second aerial tram, 15,000 feet long, is being constructed to convey ore to the new mill at Five Mile.

Since these Nettie L and Silver Cup ores have up to the present been shipped to the smelters at Trail or Nelson, the costs of smelting or mining have amounted to about $50 per ton, so that only the richest ore could be handled. Consequently large dumps of second grade ore have accumulated.

To treat these and other low grade ores in the mines, the silver mill at Five Mile is being constructed. This mill is 216½ feet long by 76½ feet wide, or 95½ feet with the retorting furnaces and stack. It is being built by the Union Iron Works of San Francisco. All the timber used for the mill, houses, offices, etc., is being cut and dressed in a sawmill on the ground. The machinery is being installed in two symmetrical units so that ore from each mine may be treated separately throughout the whole process. As this is the first silver mill erected in this country, a brief description of it will be given. The ore is delivered from the respective mines into separate grizzlies, through which the fine ore passes to bins, while the coarse rolls to the crushing floor, where there are two Blake crushers. The ore is then fed automatically into two stamp mills of 1,000 lbs. stamp each; each operated by a 75 horsepower induction motor. The pulp from the mortars is

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automatically sampled and passed to two sets of Spitzkasten hydraulic sizers, the coarse pulp going to four 10-foot Doods riffled buddles, the fine to four Vanners. The sulphurets are then dried on a drying floor, whence they are delivered by elevators and screw feeds to two Howell-White revolving roasting furnaces, at the same time being automatically mixed with salt, delivered from the salt grinders. The lead driven off by the roasting may be recovered if desired. The ore is then conveyed to a cooling floor, and then dumped into ten 5-foot amalgamating tanks, through the bottom of which steam is injected to assist in amalgamation. The charge is next run to five 8-foot settling tanks. After leaving the settlers it is strained, the quicksilver being elevated and run back to the mercury tank, supplying the amalgamating pans, and the amalgam being taken to the retort room where there are two amalgam furnaces. The quicksilver driven off from the furnace is elevated and returned to the mercury tank. Provision may be made for saving the copper if sufficient quantity is present. The power plant, in a separate building, is supplied with two Pelton wheels, electric generators, transformers, etc. The power is supplied by water brought by a 3,700 foot flume from Lardeau Creek, and delivered at the power house under 145 foot head.

The Trium mine is situated a short distance southeast of the Silver Cup, separated from it by a gulch and small ridge.

The tunnels enter the face of a cliff under a small glacier. The mode of occurrence and character of the ore is very similar to that of the Silver Cup. Indeed, from the course and dip of the Silver Cup lead it is highly probable that the Trium is on the extension of the same leads. There is, however, this difference, the northern vein sometimes traverses the southern diabase dikes, and the southern vein occurs outside this dike, with the dike as a sort of hanging wall.

In the upper part of the mine, near the bed of the glacier, the ground is frozen throughout the summer. On account of this peculiar situation this mine has not been worked in winter, and only the richest ore can be classed as first-grade ore. Notwithstanding its disadvantage it is estimated that at the close of the present season its output will have reached $140,000.

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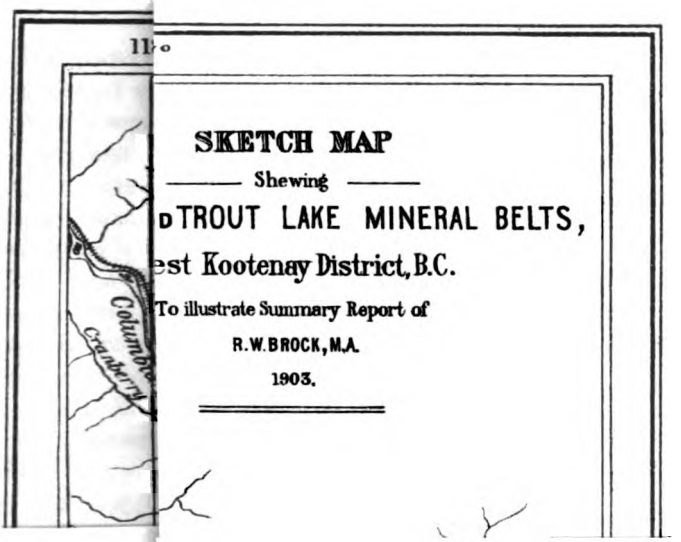

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This mineral belt extends over Silver Cup Mountain, the Cromwell and other claims being situated on it. It probably runs along the range past the head of American and Haskins Creek, but on account of the snow it was impossible to trace it up.

Some quartz claims carrying free gold have been found on this range, some containing feldspar and bearing a resemblance to acid facies of pegmatite dikes.

The lime dike series of rocks which extend along the headwaters of the tributaries of Lardeau and the west fork of the Duncan River, is also well mineralized, as has been mentioned. Veins occur both in the slates or phyllites or in the limestone itself. The Badshot, Mohican, Black Prince, Ophir Ludi and numerous other claims occur in this series of rocks.

Ores very similar to those of the central belt occur in Trout Lake and Lardeau River valley, particularly on the slopes to the south. From the position and number of locations this may be considered as forming a third mineral belt.

The claims near the valley enjoy the great advantage of being near transportation facilities, permitting a lower grade ore to be shipped, as the freight and smelting on ore delivered on Trout Lake is from $15 to $18 per ton.

The Lucky Boy claim, northwest of Trout Lake City, was shipping ore during the summer and several other claims were being developed.

THE POPLAR CREEK DISTRICT.

The basin of the Lardeau River below Trout Lake is now usually referred to as the Poplar Creek district, since the excitement and rush into the district this summer was caused by discoveries about the mouth of Poplar Creek.

The district is not altogether new to prospectors, some of the most highly-prized claims, such as the Goldsmith, were staked ten years ago and abandoned, and some prospectors have been at work ever since.

When the construction of the railway from Lardo to Trout Lake was decided upon, the district received renewed attention. The Lucky Jack, situated on the railway line, which has been re-

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sponsible for the greatest part of the enthusiasm over the district this summer, was located in 1900 by Aug. Buffalo, and abandoned after two assessments had been done. Another claim now well spoken of is the Dominion, at the mouth of Cascade Creek, the first Creek below Poplar, which was located by the same prospector, the same year, and is still held by him. But until recently, the Lardeau was regarded as purely a silver-lead dis-

Poplar Creek, September, 1903.

trict. Yet gold has been known to occur here for several years, but not until this summer did the public become agitated over the fact. In 1898, H. Rogers and Henry Schmidt located the North Star and other claims on the north side of Rapid Creek, the first creek above Poplar, about 800 feet above the Lardeau Valley. It was located on account of a galena showing, but was soon found to be auriferous. About 60 feet of work has been done on it every year since. In 1901, John Winquist located the Spy Glass, about 12 miles up Poplar Creek, which is said assayed $120 in

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gold besides carrying high silver values. In 1901 Marquis & Gilbert located the Ochre and Ophir claims on the north side of Poplar Creek, about a mile from the mouth, and 640 feet above the Lardeau Valley. In 1902 Marquis located the Gold Park, adjoining these claims, and on it last June specimens containing visible gold were found. These were exhibited in Kalso soon after and started the rush in the district, which has resulted in the discovery of numerous quartz veins yielding exceptionally

A September Camp in the Clouds. An unfavorable morning for prospecting.

rich specimens of native gold ore. All of the ground about the mouth of Poplar Creek has been staked, some of it many times over, and locations have been made from the second crossing below Cascade Creek to beyond Tenderfoot Creek. A town is springing up at the mouth of Poplar Creek.

The rocks of this lower part of the Lardeau Basin are similar to those found in the upper, and consist of greenstones and green schists, slates and phyllites with a few limestone bands and dikes

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of the yellow weathering diabase and the schist formed by its deformation. The greenstone seems to be more heavily developed here than above, and the diabase dikes to be larger and more numerous. But time did not permit a detailed examination of the whole district. The veins occur on a belt of slates and diabase dikes which crosses the Lardeau River from the northwest, above Tenderfoot Creek, and extends southwestward nearly parallel to the river across Rapid, Poplar and Cascade Creeks. On account of the snow the Silver Cup belt could not be followed southeast across the Silver Cup Mountain, but there is little doubt that the Poplar Creek belt is its southeastern continuation. This supposition is based on the character of the rocks and ores, the strike of the rocks, and the position of the belt relative to other formations. Thus the lime dike series is seen up Lake Creek, showing the rocks to be angling toward the river. In Rapid Creek boulders of a conglomerate similar to that found in Trout Lake, afford pretty good evidencee that this band is to be found up Rapid Creek, that is, it has crossed the valley and is now away to the southwest. The veins are similar in character to those of Fish River and Silver Cup Mountain already described, except that at Poplar Creek arsenic pyrite is occasionally found. But the introduction of a new mineral at a particular point in a mineral belt is no rare thing. In this part of the belt veins are very numerous. In some places they form a net work. They usually conform to two principal directions. One set runs about 290 degrees, that is, almost parallel to the formation, though its dip may vary from that of the rocks, and the second set cross-cuts the formation running nearly north and south. The claims which have received most attention, up to the time of my visit, were the Lucky Jack, Swede Group (Goldsmith), Gold Park, on Poplar Creek; North Star, on Rapid Creek; the Maggie May and Handy groups, near the railway at Tenderfoot.

The Lucky Jack is situated on the west side of the railway, about a quarter of a mile below Poplar Creek crossing. The main vein is exposed in the hillside about 100 yards from the track, standing out like a wall from the more easily weathered country rock.

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Lucky Jack Vein, Poplar Creek.

The country rock is the rusty weathering diabase schist, more or less impregnated with pyrite in small grains and veinlets. The vein is quartz two to five feet wide, standing almost vertical, with a strike of 338 degrees. A number of other veins occur on the property, but these have mostly the more westerly strikes.

The quartz is milky to watery, while carrying a little arsenopyrite which holds free gold, galena and pyrite, with, in places, very coarse free gold liberally splashed through it in bunches, masses, fibres and plates. Gold occurs in the pure quartz, in the sulphides, surrounding the sulphides in inclusions of country rock,

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or, along the walls, fine gold invisible to the eye is also found. This vein has afforded some magnificent specimens, some of the finest ore found in the province. The values are not evenly distributed, often no gold is visible, though even here the quartz is said to pan.

The occurrence of sulphide and inclusions of rock appear to be favorable indications of values. The arsenopyrite is often rich in free gold.

On the Gold Nile and Goldsmith claims, 1,400 feet above the valley and south of Poplar Creek, are a number of veins running from 280 to 293 degrees, varying from a few inches to several feet in width. They are mineralized here and there with spathic iron weathering to limonites, galena and pyrite.

From one of these veins on the Goldsmith the richest specimens yet found at Poplar Creek were obtained. One such specimen was estimated to weigh five pounds, of which about half was estimated to be gold.

The country rock here consists of slate and diabase schists. In the latter is a vein heavily mineralized with galena and blende copper and iron pyrite said to carry very high values, mostly in gold.

On the Crown King, just to the southeast, decomposed country rock, containing stringers of quartz which I panned, yielded heavily.

On the Spy Glass claim, about 12 miles up Poplar Creek the lead occurs in glassy mica schists. This rock represents a band or inclusion of the phyllite lying within the granite and altered by contact metamorphism. A quartz lead several feet wide, with bands of pyrite contains a pay streak of 6 to 8 inches, heavily mineralized with blende, tetrahedrite, galena, copper and iron pyrite. Native silver is quite abundant in it and argentite is probably present. Free gold is reported to have been found. This ore runs high in silver, and it is said also in gold.

Other claims, such as the Gold Jack group, North Star group, while the first is developed, present no new features and will be passed over.

Regarding the degree of success which will attend operations

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at Poplar Creek it is as yet too early to predict. This discovery of gold is certainly an important one. The veins are numerous and strong, and apparently persistent with depth. In places some of the veins are of very exceptional richness. As deep as they

Ascent to the upper opening in the Spy Glass Claim.

have been tested the character of the ore remains unchanged. The auriferous ground extends over a large area. Small stringers of quartz, such as that on the Crown King, will pan heavily. The galena vein on the Goldsmith has very high values somewhat evenly distributed.

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A large quantity of what should be good pay ore is already exposed, and some very rich spots have been found.

In many respects the ore reminds one of the Cariboo, in camp McKinney, which has yielded good results for years.

But information was not available on which to base an estimate of the run of mine. The values are not, and cannot be expected to be, evenly distributed, and the effect the leaner ores will have on the mill run has to be determined by actual test. If gold values should decrease somewhat with depth these deposits would conform to the general rule that free gold is concentrated in veins by surface agencies. The prospects are that some of the veins will yield highly satisfactory results, and the district as a whole merits and will no doubt receive careful exploitation.

But the success of mining enterprises depends not only on the values and extent of the ore, but on the business management. It is manifestly unfair to ask a mine to pay satisfactory dividends on over capitalization of any kind, and it is to be hoped that mistakes of this kind made in other districts will not be repeated here.

SUMMARY.

Ores, as we have seen, occur in these belts in the Lardeau, one southwest of the valley, one central from Fish River to Poplar Creek, and one along the Lardeau Duncan divide. Outside of these belts some mineralization occurs, but the main deposition, as far as observed, has taken place along these lines.

The ores occur largely in the phyllites, to some extent in the limestone, and in places in the rusty weathering diabase schist, but no mineralization of importance was observed in the green schist or the gabbroidal rocks.

The mineral zones have the following characters in common: the presence of bands of stratified rocks and the occurrence of dikes of the diabase schist, by which indeed the zones may be recognized. The veins usually occur near, along or within these dikes. The veins have two principal directions nearly parallel to the general strike of the rocks and nearly at right angles to it. The veins have largely the characters of the composite fissure type, their direction being largely determined by that of fissures

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in the rock, but replacement of the country rock has been an important process in addition to fissure filling. In places, and to some extent, the bedding planes of the country rock have been utilized by the mineralizers. The veins have been filled by aqueous mineralizing solutions, which have brought up their load of mineral matter from below. The character of the ores is not directly dependent upon the nature of the country rock.

The relationship between the diabase schist and the ores seem to have been largely physical, determining the direction of circulation of the solutions, although perhaps the carbonates and iron of the dikes might have been reached chemically with these ore bearing solutions. The deposits may possibly have a relationship to the pegmatites, accompanying the granite intrusion. The magma from which these were formed became more and more aqueous and acid as distances from the parent mass was gained and the vein material is often rich in feldspar as well as quartz. According to economic mineral contents the veins may be divided into two groups, the silver-lead vein, rich in metallic sulphides and the gold vein, poorer in these sulphides, but carrying free and combined gold. Except with respect to relative amounts of sulphides these two groups of veins are very similar. Both are characterized by quartz, carbonates, sericite, feldspar and the same or very similar sulphides. But the relationship between the two classes of veins is not clear. The galena vein in the Criterion at Fish River is later than one of the quartz veins, but may be older than the second.

The veins are found on the highest summits and in the deepest valleys. The largest number of locations have been made on the summits, but this is to be explained by the better exposures to be found there, the prospector being there unhampered by wash or vegetation.

The values are not evenly distributed, but are localized in chutes. There is often a concentration of values round carbonaceous inclusions or carbonaceous wall rock. Zinc blende and tetrahedrite are indicative of good values. Chutes are often found at the intersection of veins. Other indications of values will no doubt be noticed when further development has been done. It is

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particularly desirable that a criterion for recognizing pay quartz when gold is not visible to the naked eye should be found.

There is every indication that the veins are as persistent at depth as they are horizontally. So far as developed, the values in the silver veins have not altered in the lower workings. Since tetrahedrite, the rich silver mineral, is one of the earliest formed minerals in the vein, there is some ground for the hope that it will extend to some depth. Free gold is found at the greatest depth yet attained in the quartz claims.

WHERE TO PROSPECT.

Although all of the ground at Poplar Creek itself is staked, there remains a good deal of territory to be prospected, particularly for gold. The belt from Rapid and Tenderloin Creek to Silver Mountain is still largely free ground and should be examined, and from Silver Cup Mountain to Camborne it should also be prospected for gold. Free gold was found in the fall in the Winslow claim, across the divide from Silver Cup Mountain. It is not certain that the belt is auriferous throughout, and this point should be settled by actual examination. Whether this belt extends southeastward from Cascade Creek below Poplar is not known. The southwest belt between the valley and the granite contact, in which the Spy Glass occurs, is of some promise, and is mostly open for prospecting.

The lime dike series might also be re-examined for gold. Numerous quartz veins similar to those in the gold camps, occur in it under similar conditions, and it is quite probable that some of them are auriferous.

Quartz veins and some galena veins occur between Fish River camp, the Columbia and Revelstoke, but little is known of this district. The quartz veins seen by the writer appeared rather lean, but a closer examination is necessary before this area can be pronounced to be barren, and so far as known, prospecting might be attended with success.

From what has been said it is evident that in the Lardeau we have a young district of considerable merit and promise. The

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initial difficulties attendant upon its isolated position and mountainous character are now largely overcome, and no doubt certain portions of the district are now receiving a careful testing. If the results of this are as satisfactory as they promise to be the rapid development of this district may be predicted.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MILLER—This paper is not only of interest to mining men but to glaciologists and mountain climbers. Professor Walker has scaled the Himalayas and Dr. Coleman has done considerable climbing in the west. We shall be pleased to hear from these gentlemen.

PROF. COLEMAN—I admit that though I have done a little mountain climbing, I am very much puzzled to know how these men got into the startling attitudes that Mr. Brock has portrayed in the photos.

PROF. MILLER—I may say that Mr. Boyd, who was Mr. Brock's assistant, was quite a good football player in his day.

MR. INGALL—How far is that district from the Fish River district?

MR. BROCK—I have never gone there from Illecillewaet, but I think it is thirty-five miles.

MR. INGALL—It is very interesting to think that about forty miles north of that district, where they have such rich ores, they have identically the same formation with quite low grade ores. It seems to be just the same kind of formations on the average, forty miles away, and yet the ores are low grade, whereas in the other district they are very high grade. Has Mr. Brock any ideas of why the change occurred?

MR. BROCK—I have not an intimate knowledge of the district north and west of Camborne. I think there is no question but that the rocks of the so-called Selkirk series, along the main line of the C.P.R., represent the Lardeau rocks in a more highly metamorphosed condition. I have been up the hills at a number of

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points between Revelstoke and Fish River and have there seen quartz veins very similar in general character to the veins farther to the southeast, except that they appeared to be very lean. But there is a considerable area which cannot be said to have been carefully prospected, and there is a possibility that ore may be found.

Even the Lardeau itself has not been thoroughly prospected. All the ground around Poplar Creek is staked, but the country between Tenderfoot Creek and Silver Mountain, through which it is almost certain that the central mineral belt runs, contains a good deal of open ground, yet to be prospected for gold ores.

Gold ores have been recognized in the Lardeau for a short time only and it may very well be that gold ores occur between Camborne and the Illecillewaet which has not yet been found. Prospectors have been asking eagerly for information about that section of the country.

MR. INGALL—In the Fish River district only thirty miles to the north, there has been a considerable amount of prospecting for galena. I went through all that district, and in the Fish River district the rocks remind me of the other rocks to the south in respect to the carboniferous matter.

MR. OBALSKI—I understand that they found free gold in that lime dike, can you explain the origin of that?

MR. BROCK—I did not take time to call attention particularly to it. According to the economic conditions your veins can be divided into silver-lead and gold veins. So far I do not think that any gold veins have been found in the limestone series, but silver-lead veins have been found there. In the immediate neighborhood of the lime dike there is good indication of gold, and one claim runs quite high.

PROF. MICKLE—In the Lardeau I think the value is almost entirely in the grey copper.

MR. BROCK—The grey copper contains the highest value in silver. The zinc blende is also a good carrier of silver, but of course the chief value is in the tetrahedrite.

PROF. MICKLE—In the "Nettie L" in the first drift there was a little streak of grey copper ore that was tremendously rich,

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assaying over three thousand ounces to the ton. I understood that the galena and the zinc blende did not run more than about 50 ounces or so.

PROF. MILLER—One point in Mr. Brock's paper which struck me as being somewhat peculiar is the statement that they put men to guard ore in British Columbia that runs only $500 to the ton. Here in Ontario we do not do that (laughter). I visited some deposits in the Temiscaming district late last fall and they had ore there running $5,000 and over to the ton and they did not have anyone to guard it. You were allowed to take whatever you wanted. I got about 400 pounds myself, and my friend who was with me was a little greedier and he took 1,000 pounds (laughter). I am glad to see that we have a delegation of four or five from that district and they can speak concerning the value of these deposits.

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Journal of the Canadian Mining Institute, Vol. VII.

THE MINES OF ONTARIO.

By W. E. H. Carter, B.A.Sc., Toronto.

Toronto Meeting, March, 1904.

A very wide field for discussion is laid open by the title chosen for this paper, too wide, in fact, to be here gone into fully, so that only certain phases of the mining operations will be dealt with, and since the mines of eastern Ontario formed the subject of a paper (1) read before this Society at the 1902 session more attention will here be paid to mining in western Ontario. Probably the best ends will be served by making the present status of the mining industries the main topic and attempting to set forth the reasons for the abnormal inactivity in many of the mining districts.

The gold areas in particular are placed in a rather critical position, as the culmination of an unfortunate policy or method of mining which has prevailed from the start, and which may be summed up in the words, "inefficient management." This has arisen from the persistent disregard, at all but a few mines, of the need of employing a capable engineer as head, and out of the fact that few companies start mining with a really *bona fide* intent to see the undertaking through on a proper business basis. Until the trouble is squarely faced, realized and remedied, the same disappointing results from the mining ventures will without doubt continue.

The important historical points of the different mineral industries, so varied in this province, will also be dealt with, in connection with the above and in order to collectively summarize the mining development from the beginning.

While the mining industries in the eastern portion of Ontario are much more varied than elsewhere and the number of mines large, the value of the output is small compared with that of the

(1) Can. Min. Inst., Vol. V, "Eastern Ontario: A Region of Varied Mining Industries," by Willet G. Miller.

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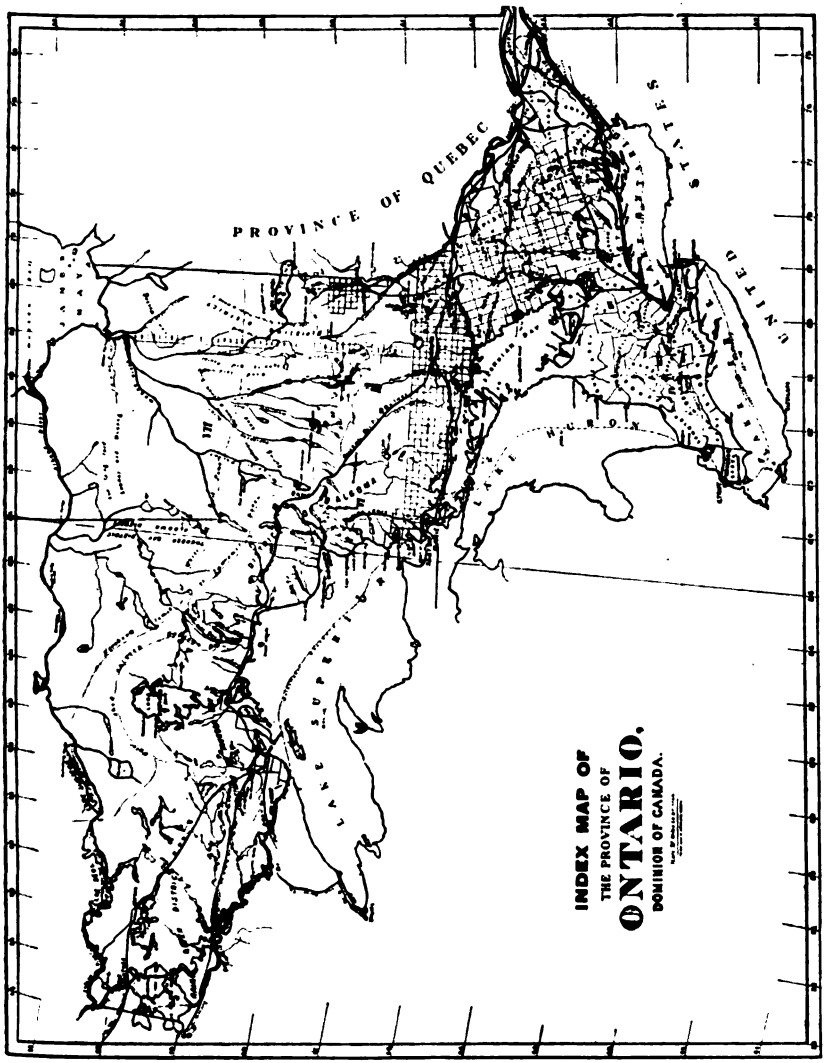

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fewer metals or minerals raised from western Ontario, which extends from Nipissing district west to Rainy River district, and this is due mainly to the product of the nickel-copper and iron mines of the latter area, and to the fact that practically the whole product is metalliferous and more valuable. There are, however, non-metallic minerals being raised, such as building stones of the greatest variety and value, from end to end of the western half of Ontario, of which but little is heard in the east on account of their distant situation and of the presence in the east of sufficient of the same class of materials for all ordinary requirements. They play an important part in the development of that end of the province simply by supplying local needs; but their value lies rather in a greatly increased future demand, a matter merely of time, than in the present small consumption. Of them no further mention will be made, since their operation comes more under the head of commercial than mining undertakings.

The facilities necessary for economic and profitable mining in Ontario are yearly increasing by the location and construction of new railways, in particular throughout this western end of the province, where they are most needed, by the settling of the country, and by the development of water powers for the transmission of electric energy to the mining and manufacturing centres. The prospector and farmer no longer confine their efforts to the older known areas, but have advanced for a hundred or two hundred miles north of the main line of the C.P.Ry. A good example of this is in the Temiscaming country, where as a natural result a railway, the Temiscaming & Northern Ontario, has followed them. Not only have good new lands been already cleared, but valuable mineral discovered, and many of those formerly known to exist are now being mined, or this year will be mined, along the road. Seldom does a railway or at least a branch line enter a new country before the prospector and farmer, and we may, therefore, expect to find that very soon other roads also will tap the new northern mineral fields, such as the northern nickel range and the iron ranges north of Sudbury, the iron ranges north of lake Superior at lake Nipigon, and the gold areas in parts of the west now distant from either of the two existing roads.

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GOLD MINES.

The first noteworthy discovery of gold was made at the Richardson mine, in Madoc township, Hastings county, in the year 1866. Since then valuable gold areas have been found from here to the western end of the province, over a distance of some 900 miles, and with nowhere a gap of more than 100 miles. And there appears no reason why gold should not be found in these stretches also when the prospector devotes his attention to them. An enumeration of the different points at which gold mining has within recent years progressed will serve to exemplify this very general distribution. From east to west the areas consist of the Eastern Ontario belt, extending through the four counties of Peterborough, Hastings, Addington and Frontenac; the Parry Sound area in the district of that name; the vicinity of Wahnapitae lake; from Sudbury west along the north shore of lake Huron; the Michipicoton area following the belt of Huronian rocks from lake Superior northeasterly to Dog and Missanabi lakes; along the north shore of lake Superior at Jackfish, Rossport and other isolated localities in the area; and from Shebandowan lake west to the lake of the Woods and north to Sturgeon lake, which last area comprises practically all of the Province west of lake Superior.

PLACERS.

Unlike most gold regions, Ontario has no placer deposits which have so far been proved of commercial value. From time to time auriferous sands have been discovered and immediately subjected to official examination. There are two main occurrences and one consists of the gravel and sand areas along the Vermilion and Wahnapitae rivers, the more important beds of which follow the Vermilion river for a stretch of 40 miles with a breadth of from one to three miles. It was generally conceded that the only feasible method of profitably working the sands would be by dredging, since the gold is mostly in fine colors and the average value of the sand not more than a few cents per cubic yard. During 1901 some tests were made with the sand with a plant erected on the ground, the idea being to combine amalgamation and

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cyanidation in the process. A forest fire wiped out the works, however, before much of value had been accomplished, and the attempt has not yet been renewed. The other area comprises the sand and gravel hills and beds in various parts of Savant lake and district, which is reached by canoe northerly from Ignace, western Ontario. These sands also cover an extensive area. They differ from the Vermilion sands, however, in that but little gold could be collected by panning, while by fire assay values in the precious metals were frequent. To quote from the report thereon by Willet G. Miller: "These values (by fire assay) come from material, which is probably more or less refractory, in the rusty fragments of rock in the gravel. Only a very small percentage of the gold can be extracted by placer methods." Gold values, per ton by assay, ran all the way from traces to $2.00. Silver appeared in traces in most of the samples.

As an example of the small local occurrences of auriferous sands or other detritus, the result of either glacial action or weathering, which may be found at many places in our gold areas, those in the arsenical gold belt in Hastings county are interesting. Besides quite small beds of auriferous sand filling depressions in the rocks in the vicinity of the Deloro and other mines, one was found on the Cook property, in Marmora township, forming the bed of a swamp of less than an acre in extent, composed of large and small angular boulders of quartz and country rock carrying weathered sulphides and compactly filled with fines of the same materials. The whole was rich in gold values. It probably represents the glacially denuded portion of one of the nearby veins, deposited as a moraine against the more solid trap country.

Eastern Ontario.

To return to the discussion of the auriferous ore bodies in place as found in the above enumerated areas: In the eastern Ontario gold belt, of which a general description has already been given before this Society and elsewhere(2), a number of mines have been producing bullion recently, although at present most

(2) Can. Min. Inst., Vol. V, pp. 233-255; Bur. Mines, Vol. XI, pp. 186-207.

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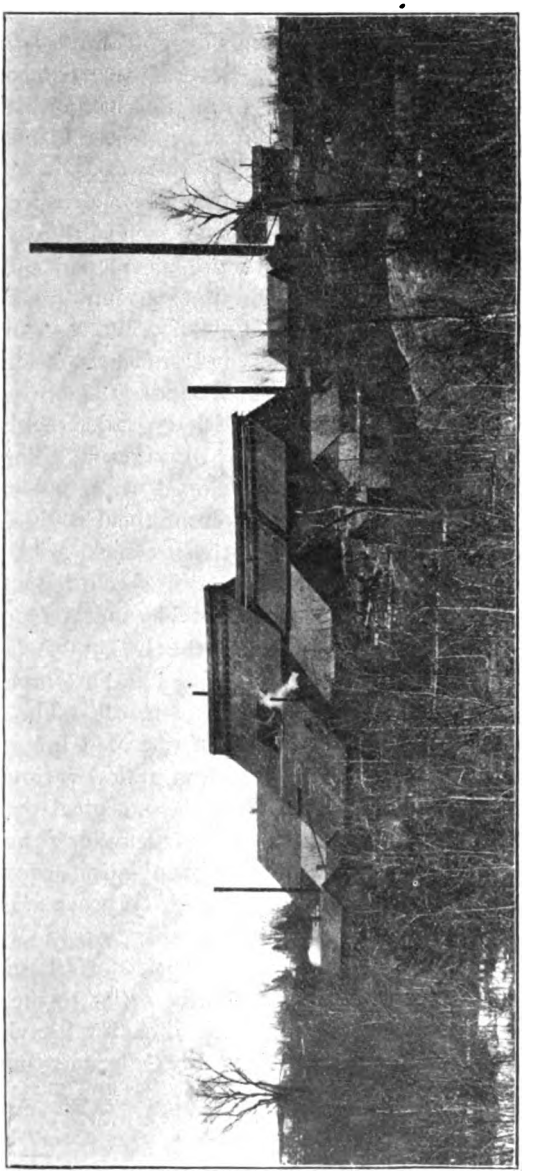

Deloro Mine : Arsenic refinery, making pure White Arsenic from mispickel concentrates.

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of the mills are closed, presumably temporarily. These include the Belmont, one of our most promising gold mines, the Deloro, the Atlas Arsenic and the Cook. Several new companies have been formed to develop other gold properties in the district, some merely prospects adjoining these known mines, and others, older mines already considerably developed.

In 1897 the Belmont mine, then merely a prospect, was acquired by the present owners, who have systematically explored most of the important showings of ore, developed a number of them, erected the present extensive mining and milling plants, and produced from that year to date 16,789.79 ounces gold bullion, valued at $289,301.76. Numerous and sufficient descriptions of the ore bodies have already been published(3), from which they are seen to be unusually large, but of low grade, requiring large milling plant and economic operation throughout. For this last, the mine is well equipped with a developed water power, and lies in a district handy to the main centres of the Province.

It would appear that amongst the arsenical-gold properties in this district an amalgamation of the different interests is necessary to bring about the continued profitable operation of the different mines, principal of which are the Deloro, Atlas Arsenic and Cook. This course has been advocated and attempted a number of times, but so far without definite result. The Deloro, a pioneer amongst these mines, has been operated off and on for the past 30 years or more, and during that period various methods for the extraction of gold values from the arsenical pyrites tried. In all of them amalgamation in one way or another formed a part. Chlorination and ordinary potassium-cyanidation proving commercially unsuccessful, the bromo-cyanide process was evolved, and has since been successfully adapted to the ore(4). The residue from the mill, after cyanidation, consists of these arsenical pyrites (mispickel) concentrates which then pass to the adjoining refinery for extraction of the arsenic. The total saving in the original gold content of the milling ore by amalgamation and

(3) Bur. Mines, Vols. X, XI, XII.

(4) "The Treatment of Auriferous Mispickel Ores," Can. Min. Inst., Vol. V.

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cyanidation averaged from 88 per cent. to 90 per cent. during four and a half years' steady work. During the five year period of operation from 1899 to 1903, 35,877 tons of ore were raised and milled, from which the total value of the gold recovered was $181,907.55, and of the arsenic $128,975.50, making a grand total value of $310,883.05, or of $8.66 per ton.

During the year the mine of the Atlas Arsenic Co., which adjoins the Deloro, was further worked, and the ore treated in the 10-stamp mill, the concentrates going to the Deloro refinery for the extraction of arsenic.

The old 20-stamp mill, in its log building on the banks of the Moira river, about one mile below the Deloro, was a year or so ago bought by the Cook Land Company and set in operation again. It has stood here over 30 years, a most interesting contrast to the economic milling methods of to-day. The stamp batteries were very light, shaky affairs, with feed boxes of sheet iron bolted on behind. In place of crushers and automatic feeders all ore was broken by sledge and fed by hand. The cams had only one long arm, which operated stamps of about 700 lbs. weight, the daily capacity being a little over one ton per stamp. About a year ago, however, the whole plant was destroyed by fire.

Parry Sound.

The occurrence of gold in the Parry Sound area first attracted attention in 1894, in the ore of the McGown mine, which lies about two miles east of the town of Parry Sound. During the following lively exploration of the surrounding field more promise was, however, given of developing a copper than a gold area, since the gold is usually associated with the copper ores bornite, chalcocite and chalcopyrite. Laurentian gneiss and mica schist compose the country, throughout all of which scattered basic dikes have at a later age been ejected. Along more or less defined mineralized zones of the gneiss or schist, or less frequently in quartz veins, the gold and copper are found. In 1898 a 10-stamp mill was erected at the McGown mine.

Wahnapitae and Lake Huron.

In the Wahnapitae area there are as yet no producing gold

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mines, the only stamp mill, at the Crystal mine, on the east side of lake Wahnapitae, having lain idle since the few runs made at the start, in 1897. This property has recently changed hands, and may, according to report, be re-opened this year.

An important discovery of gold was made last summer in the Huronian rocks in the township of Shakespeare, a short distance north of Webbwood. The metal was found, on what is now the Shakespeare mine, in unusually large nuggets, equal to anything from the gold fields of western Ontario, and in an ore body composed of quartz bands interlaminated with green schist. The existence of gold in this district, though reported before, had never been proved for certain until this find was made. Copper ores, on the other hand, occur quite frequently. Sudden discoveries of this kind are, on the whole, good for any district, and especially so for this one of ancient metamorphosed sedimentaries and of eruptive rocks, in which many minerals of economic importance may occur. From the predominance of these veins of copper pyrites interest in other minerals had somewhat lapsed.

Michipicoton and Lake Superior.

Michipicoton as a gold area was first brought to notice in 1897, and, partially aided by rumored finds of rich placer sands, a lively rush into the field followed, the route being by way of Missanabie, on the C.P.R. to the north. Now, access is had by steamer from Sault Ste. Marie in summer, and by sleigh from Ryerson near Missanabie in winter. The Grace was the first mine systematically developed and since the completion of its stamp mill, and the subsequent production during 1903 of gold bricks enthusiasm in the possibilities of the veins of the area has been considerably aroused. Already a number of other mines formerly only superficially tested have been developed fairly extensively. A stamp mill was last year erected at the Manxman mine and another is promised for the Mariposa.

The auriferous veins in the area are much alike throughout in their usual composition of white, glassy quartz containing more or less intermixed streaks of black to light green schist (remnants of the country), with little or no sulphides of any kind. They are

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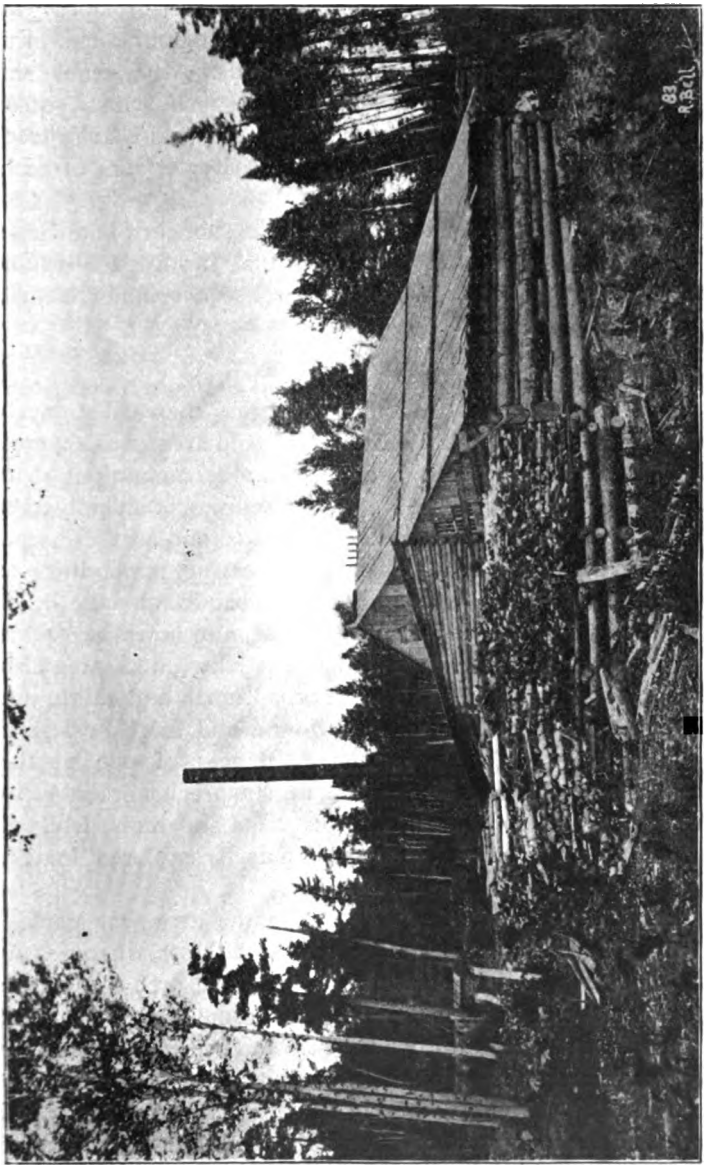

Pine Portage Mine, Lake of the Woods, 1883; one of the first stamp mills in Ontario.

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quite numerous and often of great width (30 feet or more), and confined for the most part to the Huronian series of rocks in the vicinity of the Laurentian granite and gneiss. A noticeable similarity exists between these altered traps, green schists, quartz porphyries, etc., of this Huronian area and the gold bearing rocks of western Ontario; and also between the characteristics of occurrence of the ore bodies in each.

Between Michipicoton and the western shores of lake Superior isolated gold mines have been worked, at Jackfish for instance and at Rossport, but these have not reached a commercial basis of operation as yet.

Western Ontario.

In the western Ontario gold area during the earlier days of the industry each of the newly discovered gold areas was separately designated; but with the more general examination of the country, aided by the increased railway facilities, practically every section of this immense field has been reached and all these separated areas found, as far as their gold bearing possibilities are concerned, to merge into one. From Shebandowan lake on the east, to the lake of the Woods on the west, and north beyond the C.P.R. as far as Sturgeon and Minnietakie lakes, in an area about 240 miles long east and west by 100 broad north and south, auriferous veins or deposits have been found and more or less developed within comparatively short distances of one another. Even the supposedly barren Laurentian, comprising probably two thirds of the area, contains auriferous veins and reefs, while the Huronian of the remaining one-third may be explored for gold with good chance of success throughout.

The first important find of gold in the area was made in 1871 at the Huronian mine in the township of Moss, where as early as 1883 a stamp mill was erected to treat the ore; but adverse circumstances, chiefly inaccessibility at the time, were, apparently, too much for its successful operation. The ore is unique in Ontario as containing the only known occurrence of sylvanite (gold-silver telluride). The lake of the Woods area, according to the reports, was the next point of discovery of gold, in 1878 or earlier.

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As a result of the exploration of these two fields the whole of the west has been gradually opened up.

With regard to the structural geology of the area, I quote from Dr. A. P. Coleman's summary in the report of the Bureau of Mines, vol. VI., pp. 114-115:

"The gold area of Ontario is of an almost unique kind. In many respects no other gold region can be compared directly with it, and the laws governing its auriferous deposits should be worked out for themselves. On this account it will be useful to sum up our present knowledge of its geology. There is, perhaps, no other large gold region confined to rocks of so ancient an age as the Archean; and something should, therefore, be said as to the arrangement of these rocks. In general, the excellent work of Dr. Andrew C. Lawson, formerly of the Canadian Geological Survey, now of California University, may be accepted as laying the foundation of our knowledge both of the Lake of the Woods and the Rainy Lake districts. The general principles worked out by him for these parts of the region are found to apply also to the Seine River, Manitou and other more recently discovered districts.

"As explained and mapped by Lawson, the region consists of Laurentian and Huronian rocks, the term Laurentian being used in a petrographical, not historical, sense, and the probable Huronian being called Keewatin. A group of more or less modified sedimentary rocks, consisting of sandstones, mica schists and gneisses, Lawson names Couchiching and places beneath the Huronian; but as they are seldom or never gold bearing, they require no further mention here.

"As a usual thing the so-called Laurentian rocks, consisting chiefly of granite, granite gneiss and syenite gneiss, form rounded areas half a mile to a number of miles in width; and enclosing them are great meshes of Keewatin (Huronian) schists and eruptives, generally green in color and basic in character, but sometimes pale and silicious. Lawson has proved that the granitoid rocks push up as eruptive masses through the schists, nipping in the latter as synclinal folds with bedding having a steep dip away from the Laurentian. The Huronian rocks are chiefly eruptive

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flows and metamorphosed volcanic ashes, but sometimes water-worn conglomerates. At the junction of Laurentian and Huronian there is generally a strip of greatly disturbed territory where the granite or gneiss has floated off small or large blocks of the green rocks, or has pushed dikes of granite or felsite into fissures of the Huronian. Eruptive bosses of a later granite in many places penetrate both Laurentian and Huronian, and likewise send dikes into the adjoining rock.

". . . . It is evident from the sketch just given that the region was one of great disturbance during Archean times, mountain building, earthquakes and volcanic eruptions having been active, not alone in causing the general geological relationships which we now find, but also in opening up innumerable fissures to be filled with quartz and other minerals by circulating heated waters, thus forming the present ore deposits.

"At a much later age the region, mountainous at the close of the Archean, was worn down to an approximate plain, disclosing on an ice-smoothed surface the complicated arrangement of rocks and veins now so interesting to the geologist and prospector.

"A more complete description of the geology may be found in the reports of the Geological Survey of Canada, and in previous reports of the Bureau of Mines."(5)

On account of the generally flat nature of the country the gold mines, and, in fact, practically all the deep mines with one or two unimportant exceptions, have to be opened up by shaft, instead of by tunnel, as in more mountainous districts. This makes development of the ore bodies somewhat more expensive, especially during the initial prospecting stage, than in such countries as British Columbia.

Out of the great number of auriferous veins or reefs which have undergone exploration in this western Ontario field a few have attained importance by the extent of the mining done thereon and by the gold produced, the percentage of successes being probably as great as in any other gold area in Canada. But certain

(5) Lake of the Woods, A. C. Lawson; Geol. Sur. Can., 1885, Part C C; Rainy Lake Region, 1887, Part F; Bur. Mines, Vol. IV, p. 45, etc., and Vol. VI, pp. 71-124.

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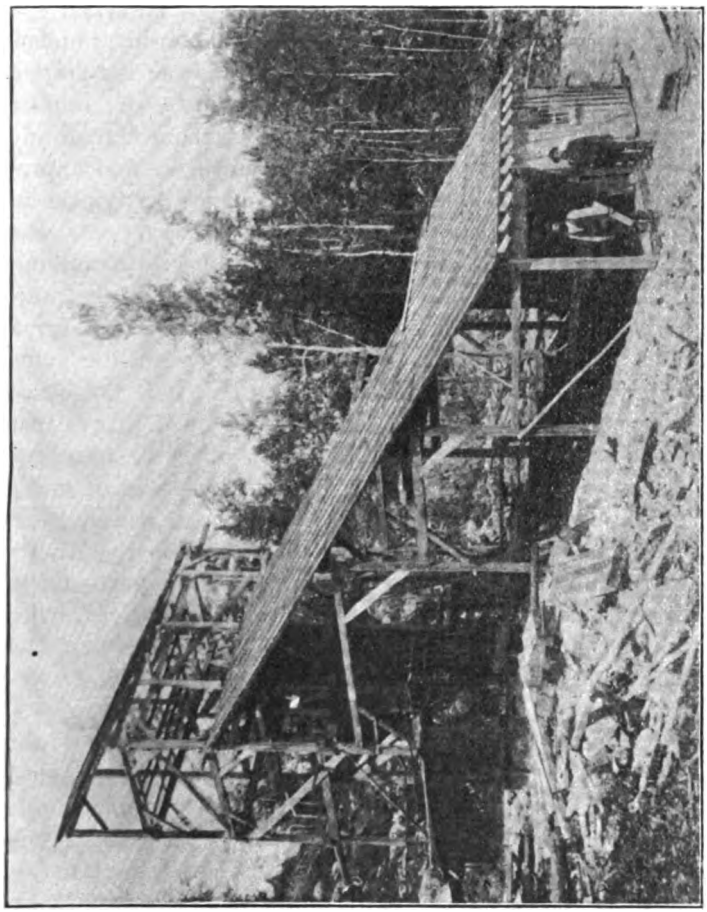

Stamp mill on Steep Rock lake, Western Ontario, 1899; frames squared by hand and lumber whip-sawn.

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serious difficulties peculiar to this part, and more or less to all of Ontario except the few big mining camps, have obtained from the start, and still exist to an important degree, which re-act to the detriment of the area. Chief of these is the almost universal disregard by the operators of the first principle of any business undertaking which is to place in charge of the work from the start a man of the necessary experience and ability. A mining enterprise need have but little more uncertainty about it than any other industry, if entered into with a full knowledge and appreciation of the risks, and with a technically qualified engineer in charge who can properly valuate these risks and govern operations accordingly. This constitutes the key to most successful mining ventures. The "practical" miner, perfectly fitted to hold the position of foreman, has not the scientific training necessary for a correct interpretation of the circumstantial evidence on the value of an ore body arising during development. What is the cause of this negligence of the common-sense way to mine? It is that the mining companies found there do not realize the necessity for such men. Usually these corporations are composed of many shareholders ignorant of everything connected with mining, and therefore lead to believe that because other mines in the neighborhood are run by practical miners so can theirs be, particularly since such practical miners may be had at a much cheaper wage than the higher-priced engineer. They do not realize that the latter may save his salary many times over by his superior knowledge and ability.

The specimen character of the auriferous deposits no doubt accounts for the ease with which these small companies are floated amongst this class of investor. Veins which may be unimportant in size and average value produce occasionally remarkably enticing free gold samples and high (but unrepresentative) assay values, on the strength of which the properties may readily be disposed of. Following the history of such concerns to the end, we find that one class after doing considerable mining and exposing some vein or rock, has spent all the working capital, with nothing to show for it, because of not having adopted from the start a comprehensive plan of development; and the other, hav-

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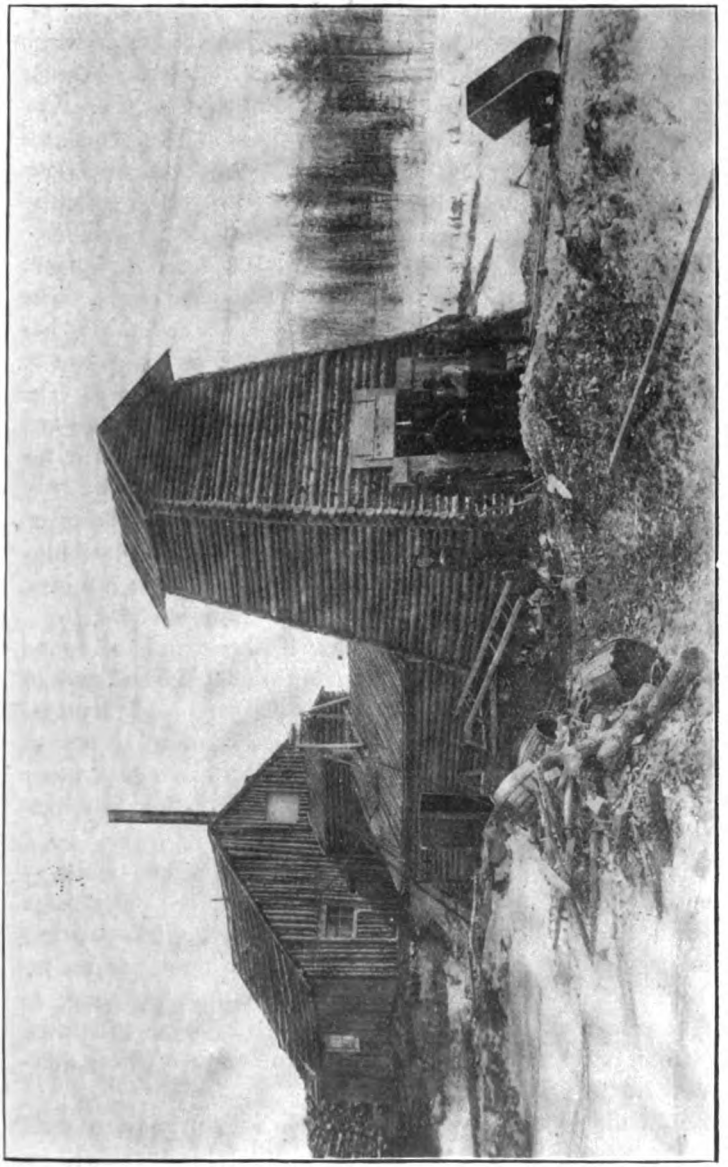

A shaft house of the early days of Western Ontario, when lumber was not obtainable.

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ing a little more cash, goes further and erects a mill, to appease the unceasing cry of the shareholders for dividends, after which its funds also are exhausted, and with no ore in sight ready for stoping from the undeveloped vein the mill stands idle. The close down of the mine is in each case certain, if not for good, for an indefinite period, for—as the investing public generally look at it—who is going to put more money in a property on which so much has already been spent with nothing to show for it?

This state of affairs accounts in large part for the apparent failure of this gold area to become generally productive. The extreme case of misdirected energies occurs where mining has been done in country rock in which absolutely no *ore body* can be seen or is indicated. Such instances are by no means rare. The most prevalent mistake, however, consists in devoting time and money to veins which are too small or narrow to warrant the expectation of ever making a paying mine of them, although they are possibly quite rich in gold. There is no excuse for taking up such properties, except it be that the operator would not employ someone who could and would properly valuate them for him that he might be induced to try a better showing elsewhere.

Plenty of other deposits may, on the other hand, be found which at least have the necessary qualifications of size, and of these quite a number, which gave reasonable promise of success on the surface, have developed into productive mines. Just at present, however, a wave of abnormal inactivity has struck many of them, due in most cases to causes quite outside the merchantable character of the ore.

Observations made during the past several years, while in close touch with the industry, have lead to the above conclusion and to the belief that the area as a gold producer is not as hopeless as appears. Let the energy and capital of the gold mining investor be directed with caution, common sense and patience to where just chance of success exists, and then at least will satisfactory proof, one way or the other, as to the value of these auriferous deposits be given.

Proof of the seriousness of the situation for this western gold area, should inexperienced management continue, is furnished by

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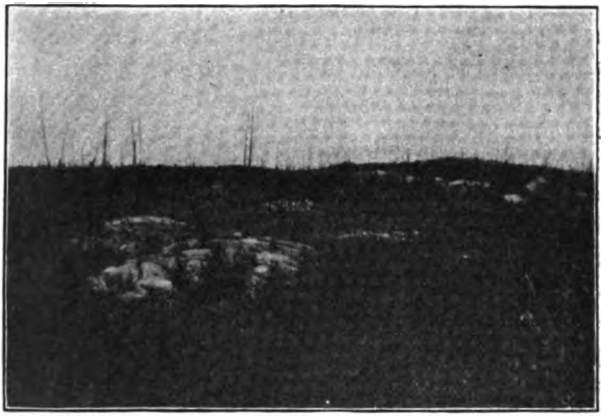
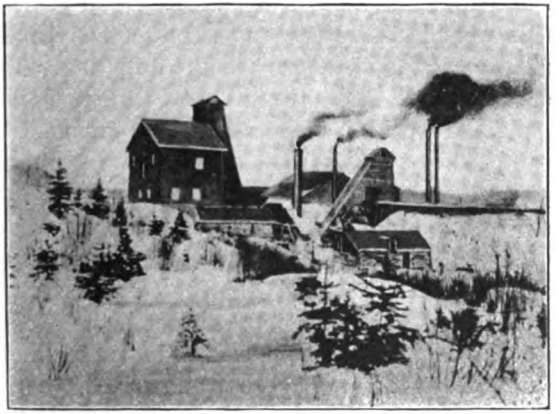


Typical country of the Island Falls area, Seine River, Rainy River District.



Mikado Mine, Lake of the Woods; shaft and rock houses, power houses, stamp mill and cyanide works.

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the fact that out of a total of 50 gold milling plants (all stamp mills but three), with the total equivalent of 558 gravity stamps, which are being or have been erected there since the start, only seven mills ran at all during the past year or so, and of them but 3, with their total of 33 stamps, attempted steady operation on what the mines produced. These plants range in size from the 1 or 2-stamp test-mill to the 40-stamp battery.

The corresponding figures for the whole Province are also worth noting, since much the same conditions exist throughout. As nearly as can now be discovered there are or were in all 74 gold mills, of which 5 were Crawfords, a few the Tremaine steam stamp, one a Krupp ball, and the rest the ordinary gravity stamp mill, having a total equivalent of about 787 gravity stamps. During the past year or so only 12 of these mills, with a total of 146 stamps, operated at all, and of them but 8, with 113 stamps, attempted continuous production, and generally only for intermittent and limited periods.

It would be unfair to let the above statement go unqualified by the greater and more normal activity of the years just previous, when the old standbys, such as the Sultana, Mikado, Deloro and others, were in full swing. During the past two years or so 22 of these mills were in operation, some continuously and the rest intermittently, with a total of 326 stamps dropping. To various financial or managerial difficulties, as well as to the state of the ore bodies, may be ascribed the present close-down of these important mines, which causes may disappear and operations be resumed at any time.

In the western Ontario area amongst the important mines may be included the Sultana, the Mikado, the Regina or Black Eagle, the Golden Star, Sakoose, Big Master and Huronian. It is not possible to give here the total output in gold of all these mines, interesting as it would be, but as an indication of the same, the amount of development may be summarized. The Sultana mine has reached a depth of between 600 and 700 feet, with lateral workings over a quarter of a mile in length, one of the stopes (the main) having a minimum cross-section of about 25′ by 25′ and a maximum of about 60′ by 120′ and extending from the first

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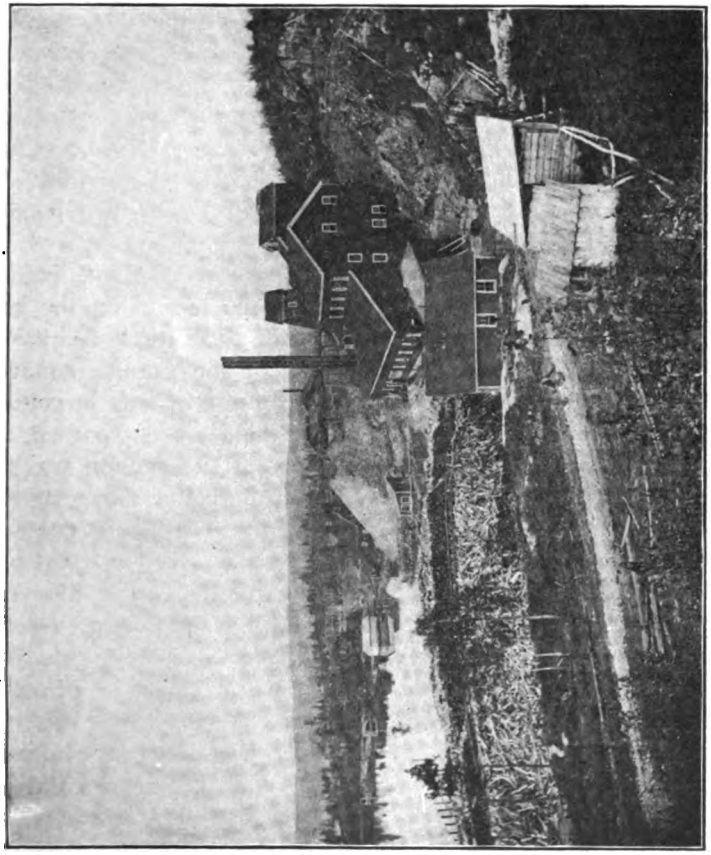

Sultana Mine, Lake of the Woods; stamp mill, shaft houses and clorination works.

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down to the seventh level, where a fault cuts it off. A 30-stamp mill, with a chlorination plant for the concentrates, has treated this ore for a number of years past, during which operations were fairly continuous. Recently the use of the Frue vanners was discontinued, and on the plates alone an extraction of 83 per cent. of the value was made. The gold bullion here has averaged a fineness of 840, typical of the gold in these non-argentiferous ore bodies of western Ontario. Mr. J. F. Caldwell, who has been closely connected with the mine since the start, states that the total production of the mine has amounted to about $500,000, and that the average value of the ore was about $8.00 per ton. An energetic effort is now being made to locate the faulted portion of the ore body.

The workings of the Mikado are even more extensive, having attained a depth of between 1,300 and 1,400 feet along the vein on the incline. The ore shoot continues down in the lower levels, but there the vein passes entirely out of the granite country, which in the upper levels it either cut through or was in contact with, and enters the trap. A drop in values accompanied the change, so that latterly ore running $5.00 or less per ton was the best obtainable. Whether a change for the better exists at still greater depths, where the vein and granite may again come in contact and values increase, remains now for others to find out, the present company having decided to cease work. The last year's operation of this mine furnishes some interesting figures of what can be done in this direction with an averagely well equipped gold property. During 1901, for a period of eight months, the ore milled averaged in value $3.14 per ton, the total extraction by amalgamation, followed by cyanidation of the tailings, amounting to 87 per cent. For the next three months the ore ran $5.07 per ton, and extraction increased to 91 per cent. This latter figure (91 per cent.) is made up of an extraction of about 65 per cent. by amalgamation and 20 per cent. by cyanidation of the tailings. About the same proportion was obtained on ore of different values. To quote from the manager's report: "Of course it was quite impossible to meet all expenses during the first period under comparison, but our total costs, including de-

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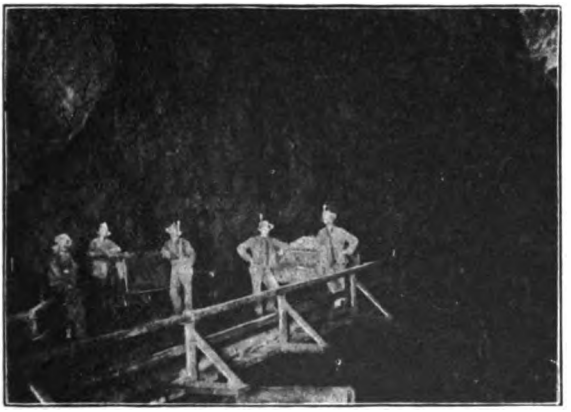
Sultana Mine : Between shaft and big stope on 5th level, ore in roof.



Sultana Mine : Bridge across big stope, 4th level.

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velopment, maintenance and fuel has been fully covered during the last four months and, indeed, a clear profit of about $600 has been made in the month of December; thus showing that with a small plant (30 stamps) and a narrow vein in a small ore shoot, it is possible to make a fair profit on ore that averages $5.00 to the ton." The Mikado mine has produced something over $500,000 in gold.

In the Black Eagle mine the bottom levels, at about 550 feet depth, disclose a vein from 6 feet to 8 feet wide. This vein fills a true fissure and extends without interruption throughout the extensive workings, but at a somewhat less average width than this. The pay ore lies in separated shoots. A new 30-stamp mill recently erected replaced the original 7 Tremaine steam stamp batteries, which, both here and elsewhere in the area, have proved unsuitable to fine crushing, besides prohibiting inside amalgamation. This mine, originally called the Regina, was found in 1894, and in 1895 a 10-stamp mill was erected and operated. Later, this milling plant was replaced by the above-mentioned 7 Tremaine batteries of 2 stamps each; but as they could not be operated successfully the present new equivalent 30 gravity stamp mill was put up in 1902. Since the beginning the ore milled has returned a little over $200,000 in gold. The ore is low grade, averaging probably between $4.00 and $5.00 per ton.

The Golden Star mine near Mine Centre has had rather a checkered career since 1898, the year of its first operation, and finally has been closed indefinitely. The trouble does not, I believe, lie so much with the condition of the ore in the vein as with the methods of development. The ore was "gutted," and after that, although the pay shoots in the bottom levels are reported to show ore well worth following, no more money could be raised to again undertake the necessary unremunerative work of opening the vein to greater depth and blocking out more ore. Mr. H. H. Wood, late manager of the mine, has kindly given me the following interesting statistics of that mine's operations, to supplement accounts already published(6). The shaft

(6) Bur. Mines, Vol. VIII, pp. 45-46, 76-79, 263, et seq.; Vol. IX, pp. 66-68; and Vol. X, pp. 79-89.

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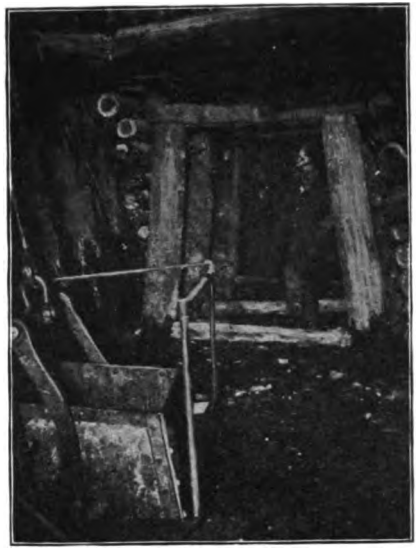
Sultana Mine; Breaking down the quartz vein in the big stope, 4th level, all rock in sight being ore.



Sultana Mine; Underground shaft station, showing level timbered through the stopes.

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reached a depth of 530 feet along the vein on its incline of 80° and is timbered with a skiproad. The drifting on the seven levels aggregates 1,894 feet, the shortest drift measuring 58 feet, and the longest, the sixth, 567 feet. The stopes exhibited a maximum width of 14 feet of ore, at which points the richest portions occurred, and a safe average of 3½ feet, and from them and the drifts there were raised and milled 19,823 tons of ore, which produced bullion valued at $160,876.35. The value saved per ton was $8.11, and that lost in the tailings $2.50, which makes the total average value of the ore amount to $10.61 per ton. An appreciable tonnage of lean ore from the last development work is included in the above total tonnage milled, which lowers the average value somewhat more than need be. The ore was crushed in a 10-stamp mill and concentrated on Frue vanners, but no attempt was made to save the values in the tailings. The ore was free milling to a varying degree, according to the part of the mine the quartz came from, the per cent. extraction by amalgamation ranging from 65 to 80. During the last operations mining and milling together were done for $3.44 per ton; but now that living, labor and transportation costs are cheaper, with the advent of a railway, the Canadian Northern, this figure should be considerably reduced.

The Sakoose mine, near Dyment, produced a good deal of gold bullion, but the attempt to carry the ore some 130 miles by rail to the stamp mill at Keewatin was found (since the ore was not unusually rich) to be unprofitable. The ore body stands ready for a more economic mode of development and treatment.

The development of the Big Master mine in the Manitou area gives interesting data on the character of similar veins traversing the green hornblendic to chloritic schists common to the country. The pay ore lies in certain well defined shoots, and when more than one occurs in the same vein they are all as a rule parallel in their dip. There may be one or two more or less extensive shoots or again a number of short ones separated by similarly short stretches of barren vein, as is the case I believe at the AL282 or Sunbeam mine near Island falls, Seine river. Also, the values do not extend into the false walls of soft altered schist, but are closely confined to the main quartz body or vein. The

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10-stamp mill at this mine has made a number of runs on the ore and produced considerable bullion; but the development of the ore body has never been sufficiently in advance of stoping to furnish a steady or continuous supply.

The gold ores of Ontario are of low grade, averaging probably less than $10.00 per ton. Continuity of the pay shoots both in size and value may be expected to reasonable depths, as shown by the development of the few deep mines above mentioned.

Some of the mining companies in this western area seem to be consumed with the desire to get hold of as much of the earth in the vicinity of their mine as possible, and according as they succeed in this so do they squander the available treasury funds. Better devote the money to developing one paying mine than to feeling rich in the possession of many idle locations. Out of over 50 companies mining on properties of various kinds during the past year or so in this area more than half held on the average between 7 and 8 times more mining land than necessary, i.e., more than the area of the one or more locations of 40 acres or so to which all mining is confined. Some of them hold 20 times more than the area of that under development. This practice of so loading the company down has in most cases no advantages either for the company or for the one mine worked, but on the other hand uses up much of the precious working capital which should be devoted to making the one mine a paying proposition.

SILVER MINES.

In the same year in which gold was discovered in the eastern townships, 1866, the first important find of silver was made on Thunder bay, lake Superior, at what was afterwards known as the Thunder Bay mine. The discovery of numerous other silver-bearing veins followed in the next few years in the same immediate area, along or near the north shore of the lake, chief of which was the Silver Islet, found two years later, in 1868. This islet was in reality merely a rock about 80 feet square, rising a few feet above the surface of the water a mile or so from the shore. Not until 1881 did the occurrence of the same precious metal in the

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Rabbit and Silver Mountain areas, 20 and 30 miles southwest of Port Arthur, also become known.

The formation in which these ores occur consists of the Animikie, the earliest of the Cambrian system. The Animikie and Nipigon rocks combine to cover a considerable area, nearly surrounding Nipigon lake and from there south to the shores, peninsulas and islands of lake Superior in the same vicinity, and southwest to the international boundary line. Nearly all the veins cutting these rocks closely resemble one another in the nature of the gangue which fills them. They are formed either entirely of quartz more or less amethystine and locally open or drusy, or entirely of white crystalline calcite with pockets of amethystine quartz, or of a general mixture of this quartz and calcite. Fragments of the wall rock are also usually included, together with scattered green and purple fluorspar. The more common metallic minerals consist of pyrite, blende, galena and chalcopyrite, while the silver occurs both as the sulphide argentite in leaves, masses or crystalline, and in the native state in leaves, grains and threads. Quite common widths for these veins are 20 and 30 feet, though the average is less than this. The tendency also is for the ore to run in narrower bands along one or the other side of the vein, particularly in the wide veins.

The distribution of the silver through the lodes is irregular, with no apparent connection between the different pay shoots. In all the mining so far done no law seems to have been discovered governing these conditions, or the mode of occurrence of the silver, which make extensive development underground necessary. This in turn has caused the close-down sooner or later of all these silver mines not now in operation. The main bonanza at the Silver Islet, for instance, produced about $2,000,000 worth of silver, and it consisted of two parallel pay shoots on adjacent branches of the lode each measuring about 100 feet along the hanging wall, about 300 feet in depth from top to bottom, that is, down to the 6th level, and from 6 inches to 2 feet in width. During two different years at the start the silver output at this mine amounted to over $640,000. At other mines similarly rich, but limited shoots were worked out. After the Silver Islet mine

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reached a depth of 1,230 feet, from the year 1870 until 1884, when it closed down, local conditions, mainly heavy inflow of water from the overlying lake and heavy charges for maintenance, forbade further development. The other bodies of ore struck in the extensive exploratory work by both mining and diamond drill during the last year or so of operation determined, however, that such veins may reasonably be expected to contain more than the original find or shoot of ore.

The Silver Islet mine produced in all about $3,250,000 in silver, most of which resulted from the smelting of the hand-cobbed ore; but subsequently a 50-stamp mill and concentrating plant was erected on the mainland opposite the island and the leaner ore run through. It was in this mill under the superintendence of Capt. Frue that the present Frue vanner of world-wide fame was invented.

The mines in the Port Arthur area produced silver more or less steadily, by the smelting of shipping ore, or of the concentrates after milling, until about 1892, when the sudden severe drop in the price of this metal caused most of them to close down. Since then the West End mine alone has operated at all extensively, and the success attained there will no doubt sooner or later lead to the re-opening of some of the other old mines. In fact a year or so ago a number of these properties, consisting of the Porcupine, Badger, Keystone and the West and East End Silver Mountain Mines, were consolidated under one ownership, with a view of working several or all on a collective plan, thereby reducing cost and increasing profits from these irregular ore bodies.

The practice at the West End mine, where operations are for the present concentrated, involves hand-sorting underground of shipping ore, that is, ore rich enough in silver to allow of direct shipment to the nearest custom smelters in the United States, and concentrating the remaining lower grade material by fairly coarse (20 mesh) wet crushing in a 20-stamp battery followed directly by hydraulic sizing and concentration on 9 Frue vanners. The mill will treat 80 tons of ore per day, or 4 tons per stamp.

There is under serious consideration the project to erect a smelter somewhere in this Port Arthur district primarily to treat

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copper ores. If built it will give further inducement to mining for silver, since all these ores could also be smelted there; probably those lean in silver as well as the rich, since the gangue of calcite would serve for fluxing other ores.

The other occurrences of silver in the Province, with the exception of the recently discovered veins in the Temiscaming area, are all in connection with other minerals of equal or greater importance, namely with gold ores, lead ores, and with gold in the copper ores of the Parry Sound district, as at the Wilcox and McGown mines. Of the argentiferous galena veins that of the Victoria mine north of Garden River station, traversing Huronian trap schists simply as a mineralized belt of the same in close proximity to the Laurentian granites, is a prominent example. Large quantities of galena have been shipped from it, and some from the Cascade mine in the same vicinity, the silver content running from a few ounces to 168 ounces per ton.

Earlier than 1890 records exist of the finding and exploration of gold and galena bearing veins carrying silver in the Temagami and Temiscaming country. Two references speak of veins 10 feet or so in width in which the galena contained from 6 to 64 ounces of silver, the lodes traversing trap and slate. None of the ores were mined on a commercial scale, however, possibly because so far away from lines of transportation. With the advent of the new Temiscaming and Northern Ontario Railway prospecting began again with renewed vigor, and amongst other important minerals the argentiferous cobalt-nickel arsenic ores were found near Haileybury. These are now being mined in a hurried attempt to ship some of the ore to the railroad while the sleighing remains. During the coming season we may expect not only extensive surface prospecting but some systematic mining of the known veins; and interest may become active again in the older fields above referred to. As official descriptions of these new ores have issued in several prominent mining journals and also in pamphlet form from the Bureau of Mines the only reference here will be to their silver content. The best specimens of the western Ontario silver ores do not compare with these new finds, so great is the percentage present in some of the veins. The silver occurs al-

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most entirely in the bright native state interwoven throughout the vein. In one vein 8 inches in width the silver content ranges from about 16 per cent. to 20 per cent. Some drift boulders of 10 to 50 lbs. weight found in the vicinity of the veins carry as high as 70 per cent. silver, the ore in place in the veins from which these masses presumably broke off locally approaching in silver content the same high figure. A carload of such ore as this is about all a man needs "to live happily ever after."

The galena ores of the eastern counties of Peterborough, Hastings, Addington, Frontenac, etc., are for the most part almost free from silver. The eastern end of the Province is not a silver area.

COPPER MINES.

The present most important copper bearing area comprises that portion of the Province bordering the north shore of lake Huron from lake Superior on the west to Wahnapitae lake on the east, and probably still farther northeasterly, since the same Huronian formation extends on to the Provincial boundary; but at that end it has not been much explored. Copper was known to exist in this region several centuries ago, the Jesuit missionaries being amongst the first to bring specimens and reports of finds back to the land of the white man. Not until 1770, however, was any attempt made to explore for the ore with the idea of mining. That year a party was sent out by English capitalists to the area in the vicinity of Sault Ste. Marie; but no success attended their efforts, doubtless for many reasons not hard to imagine in such a wild, unknown land so distant from home and supplies. Until the middle of the next century we are without record of any further attempts at mining; and then the spell was broken only by the sudden exploitation of the copper areas on the south side of the lake in Michigan. That was in 1843, and it proved sufficient to rouse an interest again in our own areas and in the possibility of finding rich copper ores here also.

Reports of the same at that time were frequent, and after examining many areas along the north shore of lake Huron the locations now known as the Bruce mines

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were in 1846 taken up as the most promising, and active development begun. There was then but one company operating in the field. Other mines, the Wellington and the Huron Copper Bay, were subsequently opened up on the extension of the same lode in a distance of about 2 miles, all showing the veins to be rich in the copper sulphide, chalcopyrite. Of the success of these mines, in spite of the great difficulties in the way of transportation, much has already been recorded and need not again be gone into here. It appears that the ore as mined contained at the start about 5 per cent. copper, the chalcopyrite being disseminated through a matrix of quartz. The veins, of which there were several roughly parallel to, as well as off-shoots from the main bodies, fill true fissures in a dike of diabase traversing the Huronian rocks of the area. A concentrator was erected and all ore raised to a 20 per cent. copper content prior to shipment to both England and the United States for complete reduction. Later, to avoid the heavy charges for transportation, smelting and the lixiviation and cementation processes were tried at the mines, but without much success. The ruins of many of the old stone buildings may still be seen. It has been ascertained that copper concentrates, precipitates, ingots (presumably of blister copper) and slags amounting to about 40,515 tons and realizing about $3,300,000 were shipped from these mines in this period of 30 years, from 1846 to 1875, during which they were worked. No other mine in Ontario, purely a copper proposition, has yet approached the output of this first copper mine.

Practically the same state of affairs exists in the silver district at the west end of lake Superior, where the Silver Islet mine, one of the first found, produced during its lifetime much more silver than has any other mine to date.

Of course, prospecting and mining covered, necessarily, very limited areas during these early years, and not until latterly is the country receiving the attention it merits either from prospector or capitalist. The lowest workings in the Bruce group are at about 550 feet; but stoping has not been carried quite so deep. It was found in the bottom levels that the copper content had decreased somewhat. In fact, according to the reports of two

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eminent engineers who examined the mine a few years ago, an average of about 3.5 per cent. is what the ore now shows, which made it impossible to profitably operate at that time when the ore had to be shipped as far as England. Just about the same time also the United States cut off the remaining market in that country by declaring an import duty on the concentrates of 5 cents per pound copper. This was no doubt the main reason for closing down in 1875. In 1899, on the strength of the above mentioned reports, the mine was taken over by another English company, put in shape for mining, and a concentrator erected of the most approved design to have a daily capacity of between 400 and 500 tons of rock. Provided the mine can show the quantity, it should be possible to now treat such ore profitably.

The Massey Station mine is one of the most promising in the area. The ore body, chalcopyrite in a silicious gangue, occurs in a wide dike of greenstone, probably a diorite, and either in or close to its contact with the quartzite country. It has a width of from 6 to 8 feet. It has been opened out to below the 600-foot level, and throughout will average about 4 per cent. copper. Some 4,000 tons of such ore was raised during the past year from the development work alone. Not until now, however, after first definitely satisfying themselves by this extensive preliminary development that the ore exists in merchantable quantity and of a quality requiring certain means of reduction, has the company given the question of treatment active consideration. This commendatory example of judicious mining might well be followed by other operators in the Province. For a month or so this spring experimental runs have been made on this ore at the Victoria mine smelter, temporarily leased for the purpose, and some blister copper produced. A 50-ton Elmore oil concentrator is now being erected at the mine, more as an experiment on this class of copper ore than with the intention of permanent adoption.

The Rock Lake mine, on the other hand, stands out in the district as a regrettable case of energy misdirected from the start. There, extensive surface plant, including mining machinery, railways and finally a 200-ton concentrator, was installed and built

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before practically anything was known of the size, value and character of the ore body. The stockholders did all this on their own account without technical advice, considering, in their excited ignorance of such things that the mere fact of having fine surface showings of ore was reason enough for their way of mining. Fortunately the ore body was large, and although opened out only to the second or 200-foot level, furnished sufficient ore at this one point of underground development to keep the concentrator running a year or more. With the workings gouged clean of ore, large additional working capital now became necessary; but this the stockholders would not put up and the property had to be closed. It is not fair to lay the blame to the ore body of which so little is known, especially when it is understood that the vein can be clearly traced for considerably more than two miles over the surface. The ore stoped from the vein ran in width from 10 to 25 feet, with an average copper content of about 3 per cent. It consists of quartz intermixed with more or less trap, the whole impregnated with the chalcopyrite and with some of the secondary copper oxides, and fills a fault fissure in the brecciated trap of this area near the contact with the Huronian quartzites.

There are a number of other promising mines in the area, amongst which may be mentioned the Superior, which has been under active exploratory mining for the last two or more years, as a result of which some remarkably rich chalcopyrite ore has been produced. On lake Wahnapitae also some copper-bearing veins have recently been opened up.

In the Parry Sound area, surrounding the town of that name, only two mines, the McGown and Wilcox, have produced and marketed any ore, and that only in limited quantities. Development throughout the area is superficial and accomplished without much system or energy. The Wilcox during the latter months of last year re-opened and raised about 2,000 tons of 4 per cent. chalcopyrite ore. The copper in the area occurs usually as chalcopyrite segregated through mineralized bands of the gneiss country; massive bornite veins up to 3 feet wide were found on the McGown intersecting these other mineralized bands.

Outside of these areas bordering the north shore of lake

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Huron the only important known occurrences of copper to the west until western Ontario is reached are those in the small areas of Nipigon rocks at Point Mamainse, Michipicoton Island, and on the islands and shores around Thunder and Black bays, in all of which it exists in the native state. At Mamainse it is found in the form of straggling masses and thin sheets in calcspar veins, and at Michipicoton as grains in an arenaceous ash-bed. Amygdaloidal traps and conglomerates comprise the copper-bearing rocks of the Black bay area, the native grains usually filling amygdaloidal cavities and small fissures.

Considerable mining for copper has been done at all these places and, judging from the statements of those who worked there, extravagance in operation and maintenance were the chief reasons the work did not longer continue. At Mamainse development was confined mainly to sinking shafts, the deepest being about 300 feet. The copper content of the ore varied considerably, but is said to have averaged about 0.75 per cent. A complete and large mining plant was installed, and an ore dressing mill of 180 tons daily capacity. This work progressed from 1883 to 1884.

Development of the Michipicoton deposits has gone on intermittently from the year 1860, and most energetically from 1880 to 1887, the work then largely confined to one location at the west end of the island where, out of the several sunk, one shaft reached a depth of 520 feet and another 360 feet. The drifting aggregated about 1,500 feet, said to be largely in stoping ground.

It may be mentioned in connection with these Ontario mines that several of the native copper mines on the south shore of the lake in Michigan are profitably mining ores that run on the average as low as 0.6 per cent. copper.

At Black bay the amygdaloids have been tested in a small way during the past several years, the work going on at one mine at the present time. No definite results as to the value of the field as a copper producer have yet been obtained.

Farther west, however, at Round lake, near Kashabowie, on the new O. & R.R. section of the C.N.Ry., and about 80 miles beyond Port Arthur, one of the pioneer mines of the area, the

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Tip-Top, has been under active and systematic development for the past two years or more. Four levels have been opened and stoping ground prepared, the output during the past year of ore, mainly from development work, amounting to a little over 4,000 tons, carrying by assay about 8 per cent. copper. If suitable arrangements can be made the company, I believe, intend erecting a small furnace either at the mine or at Port Arthur to smelt the Tip-Top ore and any other that may be raised from the other copper properties in the area, some of which (although unknown quantities as yet) were prospected recently. The silver ores, with their calcitic gangue, may also be purchased for flux and for their silver content, while coal or coke is to be obtained from the C.P.R. bins at Fort William. The project is not new; but up to the present no mine or mines has had enough ore in sight to warrant the venture.

NICKEL MINES.

A great deal has been written, in one shape or another, on the nickel areas surrounding Sudbury, which makes it unnecessary to say more than a few words here, and that with regard only to the present situation and the condition of the mines. There have been latterly but two operators in the field, the Canadian Copper Company, subsidiary to the International Nickel Company, and the Mond Nickel Company. The operations of the former far exceed all others in the business, both in the mining and the smelting departments, and are even now being magnified; while Dr. Mond's works have closed down for the present with a large stock of matte on hand.

The old Copper Cliff mine of the Canadian Copper Company, still the richest in copper of any in the district, has produced latterly about 1,000 tons per month from the bottom levels, at between 1,000 feet and 1,100 feet depth. The ore has there broken up into irregular bodies, making diamond drilling necessary in their location. Another substantial shoot of ore was recently found in this way and is now being mined. The ore averages about 12 per cent. combined metallic content (10 per cent. copper and 2 per cent. nickel).

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No. 2 mine holds good as ever in the bottom levels, at about 400 feet depth, the ore averaging about 3 per cent. nickel and 2 per cent. copper. The now abandoned open pit, measuring 217 feet in depth with an average diameter of about 120 feet and nearly vertical walls, far exceeds in size any other of these open workings at the present time. The mine is now in shape to produce 400 tons or so of ore per day with its one shaft and double skip road.

Mines Nos. 3, 4 and 5 and the Stobie are in shape to produce in large quantities, especially the first and last, when that particular class of ore in each becomes needed at the smelter.

The output of ore for a while back has come chiefly from the Creighton mine, the most recent and valuable acquisition of the company, the present rate of mining there giving over 800 tons per day. The main unbroken ore body contains, by estimate from the findings of thorough diamond drill exploration, over 3,000,000 tons of ore of a 6.5 per cent. or better nickel-copper content (about 2 of nickel to 1 of copper. There are extensions to this ore body which will considerably increase the total quantity. This estimate accounts for the ore body to a depth of but 300 feet, this being the maximum vertical depth bored by the drill, at which the width of the deposit was about 225 feet.

In order to economize in the roasting and smelting operations the entire surface works have been re-arranged, not at once but gradually during the past two years, and now a new or third smelter plant is about completed to replace both the others and also the Ontario Smelting Works near by, where the low grade matte is at present partially refined. There will be only two blast furnaces, but they will have a combined capacity of at least 1,100 tons of charge per day, and from them the molten matte will run direct to the bessemer converters in the same building and be raised to a content of about 80 per cent. nickel-copper. The accessory plant, the buildings and the new power generating station and, in fact, the general arrangement of the whole, is all after the most approved ideas, regardless of any necessary expense. Detailed descriptions of this new smelter plant appeared at the

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first of the year in several of the engineering periodicals and may also be referred to in the Thirteenth Report of the Bureau of Mines of Ontario.

With the completion of the new works all ore will be roasted in the one new or No. 3 yard. This has already grown to such an extent that it covers a distance of a mile or so from end to end, with heaps piled two deep and close together. Instead of the old dimensions of 40 feet by 80 feet plan by 10 feet high, the size of the heap has been reduced to about 25 by 40 feet plan by 6 feet high, with the expectation that it will roast better and in about one-third the time, that is, in from one to one and a half months.

The Victoria nickel mine before closing down reached a depth of 500 feet, after which diamond drill holes were bored from the bottom and from the two stopes on either side of the shaft, and the ore found to continue down to still greater depths. At some future date we may hope to see this mine again figuring in the list of producers. Since the commencement of smelting at the company's plant near the mine something over 5,000 tons of bessemerized matte containing about 80 per cent. combined nickel and copper has been produced; but only a part of this has so far been refined into the pure metals at the company's refining works in Wales. The Mond Nickel Company mined and raised ore from the North Star mine also during the past two years, shipping the same to its furnaces at Victoria.

All other mining on the nickel range has latterly been curtailed simply to exploring for other ore bodies, the work no longer limited to the vicinity of the Sudbury area but reaching out to the boundaries of the field.

With such immense and valuable ore bodies as exist in these nickel mines, producing considerably more than half the world's supply of the metal, it seems unfortunate that we Canadians should derive so little benefit from it in its final utilization. Why not have at least one of our pieces of money coined out of nickel? This, besides enlarging the limited market for nickel, would help pay due tribute to the splendid mineral resources of the Province.

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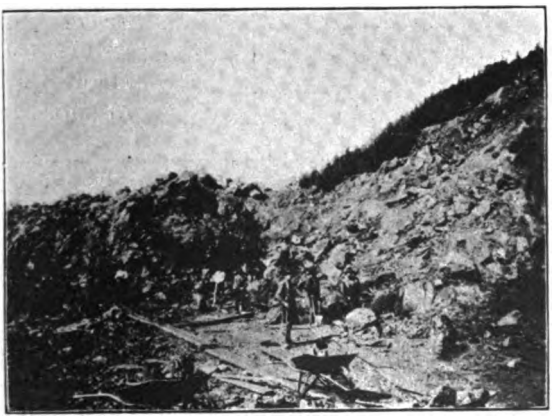
Radnor Iron Mine, Renfrew county; showing banded character of lower grade portions of ore, magnetite and silicious rock matter.

Radnor Iron Mine, Renfrew county; open cut on vein of magnetite.



Helen Iron Mine, Michipicoton; a corner of the hematite ore body.

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IRON MINES.

Iron mines are in operation in scattered localities from one end of the Province to the other. The numerous occurrences of both magnetite and hematite in the Archean rocks of eastern Ontario have already been brought to the notice of this Society, and as only a few of the mines have recently produced any ore, not much information can be added. The difficulty in the way of working these iron bodies is largely a matter of price, too low a margin of profit accruing at the present value of the abundant supply of ore from the Minnesota and Michigan mines, in competition with which ours must enter. When mined for its own consumption by a blast furnace company, as in the case of the Radnor mines in Renfrew, the property of the Canadian Iron Furnace Company, a satisfactory profit arises over buying foreign iron. The Radnor mines have produced over 25,000 tons of magnetic ore of good quality since the beginning in 1902. The ore body occurs in and is somewhat banded with a formation of micaceous gneiss. Its strike and dip are well defined.

Amongst the other mines in the eastern counties which have been doing anything of account towards raising ore may be mentioned the Moore at Eldorado, the Calabogie, the St. Charles and the Mineral Range Iron Company's properties. These last show some of the finest and largest iron ore bodies in this whole area: but for reasons mentioned above, and for lack as yet of satisfactorily cheap railway connections, steady operation and ore shipment has been delayed for the past two or more years.

The mining industry throughout eastern Ontario is not a little handicapped by this lack of adequate transportation facilities. In western Ontario the number of railroads is considerably less than here, but the want is not so greatly felt since most of the mines are of gold or silver, the product of which is easily handled. Here, however, most of the mining is for ores which have to be shipped in the crude state, and, therefore, require railroads right to the mine if possible. The needs of the mines appear at last to be forcing themselves on the powers that be, both railway companies and the Government, with the result that certain badly

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Helen Iron Mine, Michipicoton, 1901 : Steam shovels at work beneath Hematite hill.

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needed connections and extensions of present roads, such as the C.O.Ry. and the I.B. & O.Ry., are about to be constructed, and possibly a new road or two may be laid out.

The magnetic iron deposits or veins in the Laurentian gneiss and in the eruptive greenstone dikes in the gneiss of the Parry Sound district have within the last year received considerable attention by diamond drill exploration and a little mining. Magnetic surveys have frequently indicated ample quantity, but so far the necessary development has been deferred. The veins although of good quality have been found of somewhat irregular size and continuity.

About 25 miles north of Sault Ste. Marie two mines, the Loon Lake and the Williams, are being opened up on an iron range in which specular iron of excellent quality occurs. At the former there has already been raised 1,500 tons or more of ore averaging about 50 per cent. iron with almost no sulphur or phosphorus.

The ores of the Temagami lake and Hutton township areas, consisting mainly of banded magnetite and silicious material have not been mined to any extent yet. A railroad to them is a first necessity, and this the Temiscaming & Northern Ontario Railway now under construction will supply to the former area.

In the Michipicoton area iron mining ceased in the summer on account of the financial troubles of the Consolidated Lake Superior Company of Sault Ste. Marie. The Helen mine alone has produced ore; but exploratory mining and drilling on other parts of the range give promise of finding other merchantable ore bodies. The Helen has produced to date about 850,000 tons of ore. Much has already been written concerning this mine(7) making further mention unnecessary here.

Along the P.A.D. & W.Ry. west of Port Arthur, on Hunter's island and vicinity; along the Atikokan river and Steep Rock lake; along the Mattawin river; at Loon Siding, C.P.R., 20 miles northeast of Port Arthur; and in the vicinity of Nipigon lake, iron ore, both magnetite and hematite, occurs, and has during the several years past undergone rather extensive explora-

(7) Bureau of Mines, Vol. XI.

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tion by drilling and surface stripping at all these places without, however, any mines as yet opening up. Descriptive reports of these areas may be found in the different recent volumes of the Bureau of Mines, wherein also the different schemes of exploitation and the carrying out of the same are recounted. As will there be seen diamond drilling was favored and wherever possible adopted. The spasmodic energy, more or less characteristic of the work, did not provide for any extended periods of unproductive exploration so that, the first attempts not exposing any very large bodies of ore, not much has to date been accomplished towards proving the value of the outlying ranges. During the latter end of this winter the Wiley Bros. of Port Arthur sent their drill north of the C.P.R. to explore their iron claims on the range which runs northeasterly past the lower end of Black Sturgeon lake, just southwest of Nipigon lake. This is good work. When the Nipigon & St. Joe Railway makes connections with these lakes no doubt the iron ranges extending easterly from Nipigon lake will also be again explored, but on that occasion with a little more permanency than formerly, it is hoped.

The four blast furnaces, one at Hamilton and the others at Deseronto, Midland and Sault Ste. Marie, give market for the ore in our own country. The furnaces at Radnor, Quebec, have also taken a good deal of Ontario ore. There was a project on foot during the winter to erect another furnace at Port Arthur, Ont., to smelt iron from the Atikokan magnetite deposits together with any hematite which might be found on the various other ranges, and if necessary a certain amount of Mesabi ore, to make a foundry pig iron for the growing Canadian market farther west. No doubt such a plant will be erected sooner or later.

LEAD AND ZINC MINES.

These two metals complete the list of economic metalliferous products of western Ontario. Their important occurrences are confined to two areas, one that of Dorion township and vicinity and the other farther east along lake Superior, a few miles north of Rossport. In the former both galena and blende are found, separately and intermixed in calciferous veins, and from one

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carrying principally blende the Ontario Lead & Zinc Company, of Superior, Wis., has during the past year raised and shipped several hundred tons of ore. One of the old veins first mined 20 years or more ago for lead only was also worked again. The veins form a prominent feature of the country on account of their usually great width of from 10 feet to 30 feet. They traverse the Animikie rocks in connection with eruptive granites and diorites or other green schists which are well developed in bosses through the former system of rocks.

In the zinc-bearing area northeast of Rossport protracted mining work has progressed on one property only, the Zenith mine, where blende was discovered in 1881. The very intermittent development produced several thousand tons of ore averaging about 45 per cent. zinc, which was from time to time shipped to Belgium for treatment. The zinc refineries in the United States though much nearer gave a smaller profit. The ore has simply been gouged out with no attempt at systematic development of other possible bodies. A not very extensive eruption of coarse diorite probably of Huronian age interrupts at this point the Laurentian gneisses and granites of the north shore, the clean blende ore filling fissures as lenticular masses in the diorite. This and the other similar prospects in the area comprise the only known occurrences of merchantable sized bodies of blende in the Huronian system in Canada, for which reason it has a pointed value as indicating the possible existence of similar lodes in these rocks where elsewhere developed.

In eastern Ontario, about 30 miles north of Kingston, a vein of blende in the crystalline limestones was found about two years ago as a new economic mineral of that part of the Province and has been mined since from the surface down profitably, on, however, the comparatively small scale of 1,000 tons or so of 46 per cent. zinc ore a year.

One of the old lead mines, the Hollandia, in Hastings county, has during the past year been re-opened after an idle period of a number of years. Complete new mining equipment has been installed and a concentrator; the old lead smelter will be made to answer the purpose for a while longer. The galena occurs in

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a matrix of calcspar as an ore body typical of a great number of other galena deposits throughout a belt from Lanark and Frontenac counties west to Haliburton; but on account of the irregularity of occurrence of the galena in lenzes and pockets in the matrix of the veins they have hitherto not been mined at all continuously or systematically. This Hollandia mine is the first one to erect a lead concentrator in the Province. With the additional low-grade ore which may now be profitably mined, and with the Dominion Government's bounty of ¾-cent per pound of lead in the pig on all lead ore mined and smelted into pig in Canada, it should in the same way be possible to make paying propositions out of others of these deposits of galena.

IRON PYRITES MINES.

The occurrence of large deposits of iron pyrites(8) in lenzes, chimneys and veins in the talcose (chloritic) schists of Hastings county has become well known, for the past three years mining having progressed steadily on one or more of the bodies with a total production in the neighborhood of 15,000 tons of ore, averaging between 40 per cent. and 43 per cent. sulphur. All of this has been shipped to the United States for use in the manufacture of sulphuric acid. Recently mining commenced on several additional deposits in the same area in and about Madoc township, and might profitably be extended to any of the numerous other known occurrences in this part of the Province which lie near one or other of the railroads, since the ore brings at the mine from $3.00 to $3.50 per ton.

In the Michipicoton Mining Division a deposit of pyrite of apparently considerable proportions, also associated with soft chloritic schists, was bored through by diamond drill below the bed of the unwatered Boyer lake at the Helen iron mine, while hunting for extensions of the hematite ore body. The weathering and oxidation of the pyrite by which the Helen hematite resulted had not proceeded to this depth, the original mineral remaining unaltered. This pyrite may prove to be a

(8) Bur. Mines, Vol. XI, pp. 199, 295-296; Vol. XII, p. 139.

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greater asset to the owners, the Lake Superior Power Company, than its secondary hematite product might have been, providing a source of sulphur for the manufacture at Sault Ste. Marie of the sulphurous acid used in the sulphite pulp works. Ton for ton at the mine it is worth about a dollar more than the hematite ore.

In the vicinities of Rossport and Schreiber, along the north shore of lake Superior, pyrite has been found(9) at a number of points and mined, but at only one property near the latter place was ore raised and shipped. Pyrrhotite is associated with it occasionally, as also small values in gold. It occurs as veins with lenticular characteristics in the diorite areas which pierce the Laurentian gneiss of this north shore region, and therein differs from most of the other deposits in the Province, of which the country rock is a talcose or chloritic schist.

In the western end of Ontario, beyond lake Superior, massive veins or bodies of pyrite are frequent, confined as a rule to these green hornblende and chlorite schists and altered trap schists. Practically only exploratory mining has been done on any of them so far, the ore raised at a few not amounting in all to a good shipment. The better known occurrences are on Brulé creek(10), a tributary of the Kaministiquia river; near Dryden, C.P.R.; at Nickel lake(11), C.N.Ry., Watten township; and at Steep Rock lake(11), C.N.Ry. The most recent finds were made in the vicinity of this last lake during 1903 while boring with the diamond drill for iron ore. One body at a small lake called Straw Hat measures, according to the statement of Mr. R. H. Flaherty, who did the drilling, about 175 feet in width, ¾-mile in length, and contains on the average about 23 per cent. sulphur, with, however, a central lenticular band varying in width from a few feet to 20 feet, and assaying 41 per cent. sulphur, which could be profitably mined. The ore consists of pyrite interbanded with cherts in a country of green hornblende and chlorite schists.

The banded iron ores of magnetite and hematite of the north-

(9) Bur. Mines, Vol. VII, p. 78; Vol. X, pp. 89, 109.
(10) Bur. Mines, Vol. X, pp. 107-108.
(11) Bur. Mines, Vol. XI, pp. 296, 308-309.

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ern range in the vicinity of lake Temagami appear to have originated from deposits of pyrite similarly to the Michipicoton and other iron ores of western Ontario, and, if so, development of the iron will in time, no doubt, disclose merchantable pyrite ores in this area also. Quite a number of undeveloped prospects for pyrite unconnected with any iron ore are already known in this most interesting and rich mineral district, and one of them on Net lake, along the line of the T. & N.O.Ry., is now being mined. Another on James lake assays from 42 per cent. to 44 per cent. sulphur.

CORUNDUM MINES.

This abrasive mineral was first discovered in Canada in 1896, in the township of Carlow, county of Hastings, Ontario, and in the two years following received particular attention in the way of exploration of the area of occurrence by Provincial and Dominion geologists, whose exhaustive reports(12) appeared shortly after. No discussion, therefore, need be here undertaken on the geologic phase of the present situation of the industry. The corundum is associated, as a constituent, with igneous rocks embracing the ordinary varieties of syenite, syenite pegmatite, nepheline syenite and anorthosite, and is always crystalline and disseminated. Where mined so far the rock as roughly sorted has contained 10 per cent. or better of corundum, which is a probable average of the various deposits now opened up. Further work in the field by private enterprise has increased the number of known corundum deposits considerably, but only two additional operators have appeared, making a total of three. The Canada Corundum Company, the pioneer, considering, after its four or five years of fairly steady experimental operation on a small scale, that an efficient process of concentration or refining of the corundum-bearing rock has been evolved, has during the past year erected a new plant of very much larger capacity, in fact, to treat about 200 tons of rock per day. This has been completed and started running in March. The method of ore extraction is entirely by quarrying. The fin-

(12) Bur. Mines, Vols. VII and VIII; Geol. Survey of Canada, Reports.

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ished article is nearly pure corundum, graded into some 15 or 20 different sizes, from No. 12 mesh to No. 200, and is sold in part to manufacturers in the United States, but principally to the Hart Corundum Company at Hamilton and there made into wheels and various other abrasive goods. In the new refinery the process differs from that in the original plant in that coarse concentration on jigs is done away with, the whole product from the mine passing over the concentration tables, Overstroms, as fines, but closely sized for each table. The efficiency of the process depends directly on the degree of exactness with which the fines or slime pulp for any table is sized, because of the closeness of the specific gravities of the two minerals, corundum and feldspar, to be separated.

A few miles west of the above mine and works the Ontario Corundum Company has since 1902 been getting out corundum rock, sorting it as clean as possible by hand, and then shipping to the United States for complete separation. Latterly this preliminary concentration has been assisted by mechanical means in a small plant. The quarry exhibits ore of the same class and quality as at the other mines.

About the same distance to the north the third operator, the Corundum Refiners, Limited, has opened up quarries on other corundum deposits with the intention of shortly erecting another refinery in the district.

Interest in this economic mineral has increased considerably now that the abrasive market is likely to be appreciably affected by a continuous supply from these mines. Although costing more to produce than its rival, emery, the superior quality of the corundum for many abrasive uses appears to more than compensate for the difference. Unlike emery it does not destroy the temper of the tool or other metal article ground.

GRAPHITE MINES.

The industry of mining and refining this mineral can point to but one steadily producing mine, the Black Donald, in Renfrew county, within recent years, although others have been worked from time to time to appreciably increase the output in Ontario.

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These others include such as the McConnell mine near Perth, and the Allenhurst, in Denbigh township, a few miles east of the Black Donald mine. The ore of the Black Donald occurs as a vein in crystalline limestone of Archean age, its width gradually increasing from 15 feet at one end to 26 feet at the other underground face 400 feet distant. Its carbon content averages about 65 per cent., composed of the amorphous and the flake or crystalline varieties in the proportions of 45 per cent. and 20 per cent. respectively of the whole vein filling. All of the amorphous running 50 per cent. or over of carbon is sorted out and shipped in the crude state to be ground up elsewhere for a foundry facing product, while the remainder down to a 10 per cent. or 15 per cent. material is refined in a mill at the mine into nine grades of flake, mixed flake and amorphous (finer), and amorphous (finest), these ranging in purity from 96 per cent. down to 54 per cent. respectively. A developed water power on the Madawaska river, with electric power transmission to the mine and works, allows of economic operation.

The Allanhurst ore is similar in character to the Black Donald, while that of the McConnel is entirely flake. Throughout these counties of Renfrew, Addington, Frontenac and Lanark are numerous other occurrences of the mineral, some of which with their small amount of development already give prospect of becoming paying mines. The deposits across the Ottawa river, in Quebec, produce only flake and crystalline graphite, which, while forming the most valuable variety for use in the manufacture of crucibles, is too expensive for foundry facings, paint, stove polish and other such purposes where extreme purity is not essential. The Ontario amorphous deposits therefore supply a large market.

MICA MINES.

Previous to the year 1896 mica was obtained in Ontario almost entirely as a by-product from the mining of apatite or phosphate, the average yearly output amounting to considerably less than 100 tons. Between then and 1898 the relative importance in these deposits of the two associated minerals became gradually

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reversed, owing to extraneous conditions, such as, on the one hand, the opening up of many other much larger and more cheaply workable phosphate mines in the Carolinas and Florida, and, on the other hand, the utilization on a greatly increased scale of mica, as an insulator in electrical machines and apparatus, this latter mainly the result of the invention of the more generally applicable micanite or built up mica board.

The yearly production of mica reported to the Bureau of Mines is at best only a fairly close approximation of the actual output, because of the difficulty of getting at the numerous small and unpretentious operators, such as farmers who work their little pits during spare days. In 1899, however, the figures showed a rise to 266 tons mica for the year, worth $38,000. In 1900 the output was 643 tons, worth $91,750, and in 1903 was 948 tons worth $102,205. The number of mines in operation in any one year is about 15, of which one, the Lacey, at Sydenham, raised in 1903 about 65 per cent. of the yearly product, with but 45 or 50 men on the pay roll. The mica in this mine occurs in places almost massive and in extraordinary large crystals. Dimensions of 5 feet across the face by a proportionate depth are not uncommon, while one measured nine feet across. One such crystal, 3 feet by 5 feet face by 4 feet thick, contains 60 cubic feet and will weigh about 10,000 lbs., at least half of which in a good crystal will form marketable mica, and at a rough average of 20 cents a pound will be worth $1,000. Great skill is required in drilling and blasting out the mica in order not to seriously damage the crystals. Out of the rough mica raised from the mine only 25 per cent. or thereabouts reaches the market, the remaining 75 per cent. going to waste in the various trimming processes, where the flawed (fissured or spotted, etc.) portions are removed.

The geologic occurrence of the mica is described in a number of publications(13). The crystals lie embedded in irregular dikes of pyroxene with or without associated calcite, the pyroxene penetrating the granite or gneiss country. The mica-bearing portion of the pyroxene forms a chimney or chute most frequently,

(13) Reports Bur. Mines and Geol. Sur. of Can.; and Can. Min. Inst., Vol. VII, "The Occurrences, Production and Uses of Mica."

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but when, as is occasionally the case, it is more veinlike it has no great continuity and generally is definitely determinable as an elongated lenz. For this reason few of the mines have attained imposing size, being simply open pits, or extensions down of the same subsequently timbered over and worked as a large irregular shaft. The deepest mine is the Stoness, in Loughboro township, where such a shaft was sunk 425 feet, having an average cross-section of about 20 feet by 30 feet, and an incline of 25 degrees from the horizontal. The Pike Lake mine, practically the only one from which white mica or muscovite has been produced, was worked as an immense quarry three or four hundred feet in length by two-thirds this in width and about 60 feet deep, the merchantable sized mica occurring throughout a dike of pyroxene in numerous chimneys or large pockets.

Most of the mica is of the amber variety, called phlogopite, and is equal to or better than any other found in the world for the purpose of electrical insulation. The product of these mines is trimmed in Ontario, some of the larger shops also splitting for mica board, prior to shipment to the largest consumers, the General Electric Company and the Westinghouse Electric Company in the United States. A fair proportion is manufactured into the finished articles in this country, as at the Canadian General Electric Company's works and numerous smaller electrical supply concerns. At Montreal much of the scrap mica is used for making boiler covering.

The only other important mica fields are in the two Provinces of Bengal and Madras, in India, where in 1902 the production of mica was 1,095 short tons, against Canada's 1,560 tons or Ontario's 1,000 tons. In India 130 mines combined to raise the above tonnage, with the employment of 9,219 laborers, as against Ontario's 15 mines, employing 110 men. The total reported output for all countries in 1902 was 2,905 short tons, so that Ontario's contribution amounts to more than one-third.

The large mica crystals which formerly brought such fancy prices are now very little used. In fact, most of the product of the mine is cut down to the more generally applicable sizes of 1 by 3, 2 by 3 and 2 by 4 inches, for which the prices at the mine are

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per pound about 7 to 9, 15 to 20 and 25 to 30 cents respectively. These sizes may then be turned into micanite or mica board.

OTHER MINES.

In addition to the foregoing mines there are a number of others of different minerals which deserve mention, although at the present time not a great deal more information can be supplemented to the existing accounts of the same in the recent Bureau of Mines reports and elsewhere. These consist of the mines of molybdenum, platinum, feldspar, gypsum, actinolite, talc and asbestus.

Two molybdenite deposits have been mined within the past two years, and from both ore of good quality raised. Previous to 1902, although molybdenum was known to occur in Ontario in numerous localities, particularly throughout the Archaean rocks of the eastern portion, no attempt had ever been made to test and mine the deposits. One of the important finds is near Norland, Victoria county, from which several tons of ore, unusually rich for this disseminated class of occurrence, were raised, in fact, 3¼ tons valued at $400. The writer has had concentration tests made of it by the Haultain-Stovel oil process, at Nelson, B.C., with most satisfactory results, the flakes of molybdenits down to the finest particles being separated almost completely and cleanly from the gangue. The other property which has been worked lies near Tamworth, in Sheffield township, Addington county, and from it last fall a considerable tonnage of ore was raised, of which 85 tons, valued at $1,275, were shipped to chemical manufacturers in the United States. This ore contained about 2 per cent. molybdenum. A certain amount of surface prospecting has progressed on some of the other occurrences, which completes the development in this vicinity.

The metal occurs as the sulphide molybdenite, in flakes of a size from the merest particle up to 3 and 4 inches across, and disseminated through a variety of igneous rocks such as gneiss, greenstones and pyroxene. Where the rock matrix weathers easily the molybdenite frequently decomposes to a yellowish oxide, which requires other means of separation than a mechanical pro-

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cess. Large flake molybdenite was reported recently to have been discovered in northwestern Ontario in the Lac Suel area, but there, as elsewhere in this Province, in the disseminated state. In British Columbia and a few localities in the western States it, on the other hand, occurs in massive veins up to 8 inches or so in width.

Platinum has been found in appreciable and mechanically separable quantities in but one place in Ontario, namely, at the Vermilion nickel mine, in Denison township, and there as a hitherto unknown compound of this and other metals of the same group (these last in very minor proportions) with arsenic. It has been given the formula $PtAs_2$, and the name sperrylite, and is obtained together with the gold by mechanical means from the decomposed mineralized norite or gabbro forming the surface of the nickeliferous pyrrhotite ore body. By analysis it contains platinum 52.57 per cent., arsenic 40.98 per cent., oxide of tin 4.62 per cent., and the remainder in antimony, rhodium, palladium and iron. This mine was re-opened about the first of this year by the owners, the Canadian Copper Company, and we may, therefore, expect to have an appreciable quantity of platinum added to the mineral production of the Province, either as the mineral sperrylite or later by separation as pure platinum from the nickel-copper mattes from the smelters. Most, if not all, of the other pyrrhotite ores of this nickel range contain a small percentage of platinum, probably in this state of combination as sperrylite, which is subsequently separated with the other precious metals in the final treatment or refining of the nickel-copper mattes obtained from smelting the ores.

A year or so ago platinum was reported to have been found in some of the eruptive rocks near Wabigoon, Rainy River district, but beyond a little surface mining and analysing of samples nothing much was accomplished in the way of opening up and determining the nature of the occurrence as to whether or not it is of commercial value.

The mining or rather quarrying of feldspar has extended to a number of other properties in the immediate vicinity of the pioneer mine, the Richardson, in Bedford township, north of

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Kingston. The newer workings give promise of also developing into large producers, the feldspar at most of them equalling that of the Richardson. Some are raising a white feldspar, but it appears to be quite suitable for the same purposes as the pink variety (microcline) in the manufacture of pottery and for glazing tiles and other enamelled ware. The production of this mineral has increased rapidly since it was first mined in the winter of 1900-1901, the output for 1903 from about 5 properties amounting to 15,296 tons worth $20,046. This so far has all been shipped to pottery works in the United States.

The methods of mining are of the simplest, the rock being quarried in great masses onto the floor of the pits, there cobbed and sorted clean, and then raised by derrick either by horse or steam power. It is immediately hauled to the railway for shipment. Great care must be exercised after the feldspar leaves the pit that it be not contaminated with any foreign material, since this causes discoloration when it is fused and spoils it for pottery making.

Gypsum mining in Ontario is confined to the banks of the Grand river, near Paris, where the mineral occurs(14), filling irregular cracks in beds of shale of the Onondaga formation and constituting about 15 per cent. of the material as mined. It is there manufactured into a fertilizer and into alabastine, "Paristone," and other wall preparations.

Vaster beds than these have been discovered(15) in the Devonian limestone of northern Ontario, near James Bay, outcropping along the Moose or Missanabie, the Abitibi, the French and other rivers, and appearing to indicate that one continuous bed or belt of the mineral passes from one to the other of all these showings. The gypsum occurs in them massive and practically clean of limestone over large areas. The lack, however, of any means of shipment to or from this distant locality has of course prohibited all attempt at mining. The Temiscaming & Northern Ontario Railway is rapidly creeping northwards, where in its ultimate extension to a seaport on James Bay it will pass over the deposits and be

(14) Bur. Mines, Vol. XII, p. 147.
(15) Bur. Mines, Vol. XIII.

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probably the first means of converting them into a merchantable mineral.

The actinolite and talc mines of Hastings county have worked along in a small way, but occasion no particular additional description in this paper. The James actinolite deposit at Actinolite has been producing and the mill grinding to a finished article for roofing material, etc., for the past 20 years or more.

The Henderson talc mine contains a mineral of excellent quality and purity, suitable for the most delicate toilet powders, etc. On account of its foliated structure it can, however, only be used for crushing to powders and is therefore excluded from the market for such purposes as gas and acetylene burner tips which require the hard, massive variety.

In Hastings county, near Actinolite, a mine was opened last year for the production of short fibre asbestus, the formation in which the mineral occurs being the same as that of the actinolite mines, namely a blackish-green hornblende or amphibolite rock. often schistose in structure. A mill was erected for the separation of the asbestus fibre for use in the manufacture, from the best of it, of boiler covering, and from the remainder wall plaster. It is not as yet an extensive industry.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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Journal of the Canadian Mining Institute, Vol. VII.

THE STUDY OF STRATIGRAPHY.

By Dr. W. A. Parks, University of Toronto.

Toronto Meeting, March, 1904.

This present paper is in no way to be considered in the light of an essay on the subject of stratigraphy, but rather as a plea for more extended investigation in that particular branch of geological science. In venturing to draw the attention of the members of the Institute to this subject the writer finds his excuse in the lamentable lack of definite information regarding the matter and distribution of the stratified rocks, more particularly of Ontario. We, as an Institute, are directly concerned with the winning of the mineral wealth of Canada, and it is but natural that the attention of the members should be directed to the immediate problems connected with the getting of valuable substances from the bowels of the earth. However, there is no gentleman present so short sighted as to disregard the importance of those general geological phenomena which are so intimately connected with the nature and distribution of ore bodies. We are, however, apt to forget that a large portion of our mineral wealth is derived from the Palaeozoic and other stratified rocks, and while we are willing to recognize the importance of geological investigation in connection with the ore deposits of the crystalline schists, there is a growing tendency to disregard similar inquiry into the conditions surrounding those deposits associated with the stratified rocks. The general attitude of the mining community in this matter is necessarily reflected on the councils of those in charge of the government surveys, and in consequence we find that the attention of the authorities is directed almost entirely to the prosecution of investigation in our Archean regions to the decided detriment of stratigraphical study. The natural outcome of this neglect is seen in the curricula of our institutions of learning, where we find heavy courses in mineralogy, petrography, ore deposits, etc., with a minimum attention to the stratigraphical and palaeontological side of the question. It would be a matter of some diffi-

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culty to quote the exact figures, but there is no doubt that a very large percentage of those devoting their lives to geological work make a specialty of those branches which the mining community and the general public are disposed to regard as all important. We have recently received copies of the mining statistics of Ontario and of the Dominion. Let me direct your attention to these publications in order to see what portion of our mineral production is taken from the stratified deposits.

In the pamphlet on the mineral production of Ontario for 1903 we find that the returns show, for metallic substances, the value of $5,242,575.00, as contrasted with $7,528,018.00 for the non-metallic.

These figures, however, do not exactly represent the relative value of the production from the crystalline and from the stratified rocks. The following retabulation of the figures of the director of the Bureau of Mines will present the statistics in the manner that the writer would like to impress on the members of the Institute:

FROM CRYSTALLINE ROCKS.

Gold	$ 188,036
Silver	8,949
Copper	716,726
Nickel	2,499,068
Iron Ore	450,099
Pig Iron	1,491,696
Steel	304,580
Lead	1,500
Molybdenite	1,275
Zinc Ore	17,000
Actinolite	1,650
Arsenic	15,420
Corundum	87,600
Feldspar	20,046
Graphite	20,636
Iron Pyrite	21,693
Mica	102,205
Talc	2,625
	$5,950,804
Less value of Ontario ore smelted into pig iron and iron converted into steel	436,354
	$5,514.450

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FROM THE STRATIFIED ROCKS.

Drain tile	$ 227,000
Brick and Terra Cotta	1,825,538
Building stone, etc.	845,000
Carbide of Calcium	144,000
Cement	1,252,118
Gypsum	7,910
Lime	520,000
Natural Gas	196,535
Peat fuel	3,300
Petroleum	1,586,674
Pottery	160,000
Salt	388,097
Sewer Pipe	199,971
	$7,256,143

This table serves to indicate the nature of the substances derived from the stratified deposits of Ontario and reveals the fact that considerably more than half the value of our mineral product is due to the stratified rocks.

The summary report of the Geological Survey of Canada for 1903 places the total metallic products at $35,792,325, and the total non-metallic at $27,773,472. Making the same corrections as in the case of Ontario we find that of the non-metallic output $1,820,236 may be ascribed to the crystalline rocks, so that the value of the products from that series becomes $37,612,561, and the stratified rocks are responsible for $25,952,911. In this case the valuable substances derived from the stratified rocks amount to less than half the total production, but still represent an industry of enormous magnitude. If we except the Yukon gold production, which must be regarded as a somewhat extraneous and doubtful factor, the yield from the crystalline rocks would fall to considerably less than half the total production. Figures as expressive as these could be compiled for other countries besides Canada. It would probably not be incorrect to say that fully half the mineral wealth of the world is to be found in the stratified rocks. In view of this fact it is rather remarkable that our country is inclined to overlook the importance of close and painstaking investigation into these geological units which are so intimately connected with our oil and gas, with our coal and salt and with the numerous other products already enumerated.

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The reason of this neglect is to be sought in two directions: first, in the fact that many of the deposits contained in the stratified rocks are so easily obtained that, at first sight, we are apt to consider that the geological conditions are of less importance than in the Archean areas. Limestone is simply limestone, and there is plenty of it, why should we make any attempt to improve our buildings by knowing where to look for a better quality of stone? Why should we investigate the question of pure lime when a dirty magnesian or ferruginous variety will answer the purpose? We do not talk that way with regard to the metalliferous deposits, and we are ceasing to do so in reference to our building materials. We must remember that if bountiful nature has scattered limestone, sandstone and shales over a large portion of Canada, she has been pleased to mix the good with the bad, and we must recognize the fact that, if we are to have the best, the same attention must be paid to the working out of the complicated geological relations that we do not begrudge to expend on the igneous and metamorphic rocks. The second and more important reason why there is a tendency to neglect stratigraphy is the great difficulty of the subject. The study of the stratified rocks can not be carried on without the assistance of the science of Palaeontology. The average mining man knows little or nothing of this subject, and there are, I am sorry to say, many who do not hesitate to express the opinion that palaeontology is altogether foreign to the work of a mining engineer. It is true that time will not permit the active exploiter of mining lands to study a complex subject which really demands the undivided attention of those who embrace it. It is impossible to urge the study of fossils on mining men in general, but a great step forward in the development of our resources will be achieved when every mining engineer and every surveyor in the land recognizes the great importance of stratigraphical and Palaeontological investigation. Then there will be some encouragement for men to devote their energies and abilities to the working out of the great problems underlying the winning of coal, gas, oil, salt, gypsum, clay products and the substances too numerous to mention wrapped up in the series of stratified deposits in Canada. While, therefore, every mining

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engineer can not be expected to acquaint himself with the details of this complicated science, there should be men in the different parts of the country to whom problems connected with the stratified rocks might be referred. This result can only be achieved when members of this Institute and the other mining men of the country insist on the services of such men being available. The law of supply and demand will do the rest.

Confining our attention to Ontario, let us see how far behind we are in this respect and what problems await solution. In 1863, appeared the Geology of Canada, containing the results of Sir Wm. Logan's investigations. With the exception of a few desultory papers practically nothing has been done from that time to the present to establish in more detail the sequence of our Palaeozic rocks. Michigan has tackled the problem, Ohio has gone ahead and New York has done wonders, while Ontario has stood still. Our very terms are antiquated. The leading American geologists no longer employ the term *Hudson River*. *Corniferous*, and *Helderberg* are also abandoned, and other old and familiar formations are now so much better understood that their names are lost in the new nomenclature arising out of more minute subdivision. There is not a map in existence showing the difference between the Lorraine and Richmond series in Ontario. The transition from the Niagara to the Guelph is most imperfectly understood. The possible correlation of the Sylvania sandstone of Ohio and Michigan with certain phases of our Oriskani awaits confirmation. The complicated series of deposits embraced erroneously under the term *Corniferous* must be studied in the field, and the sequence of the various factors established. The position of folds, anticlines and minor fluctuations in the series must be located before we can intelligently study the oil and gas problem.

North of the continental fieight of land is an immense area of Palaeozoic rocks of which we know practically nothing. They are mapped on the plans of the Geological Survey as *Devonian*, or in some places possibly *Silurian*. Think of that for detail, in these days of our vaunted scientific accuracy! Who can say what those rocks contain? First we must know more of their geological age, we must be able to correlate them with the series south of

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the great divide and we must have maps and more detailed information of their physical condition as well as of their fossil contents. But it is unnecessary to multiply examples; we must admit that a great want exists and we must look for the best means to meet that want.

The Geological Survey of Canada has done much to further our knowledge of the geology of the country, it fact it might be said that the department has done wonders, considering the small grant available. That most of this work has been done on the Archean regions is owing to the fact that it has been your wish that it should be so. The public demand necessarily controls the action of those in charge of the Survey, and there can be no doubt that if the mining men of the country desired to see more detailed maps and to possess more exact information regarding our Palaeozoic areas an increasing portion of the geological appropriation would be devoted to that end. That the same is true of the Bureau of Mines of Ontario the present writer is well assured.

If every man directly or indirectly connected with the mining industry would throw his influence in favor of more extended operations on our Palaeozoic areas both the Dominion and provincial authorities would feel justified in preparing the desired maps and in bringing our information regarding these important sediments into a condition comparable with that presented by the neighboring States of the American Union. This work would stimulate young men to pursue this branch of geological science and would reduce the undue percentage of those making a specialty of the study of petrography and allied subjects. The natural outcome of this would be that the country and the mining community would have a greater number of experts capable of passing judgment on the many questions arising in connection with the varied non-metallic deposits of the Palaeozoic rocks.

In connection with the detailed study of stratigraphy, as already pointed out, the allied subject of palaeontology is indispensable; the proper prosecution of research in this branch can only be carried on by the possession of extensive collections of fossils. Such collections must be obtained by the government

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geologists and should be preserved, not only in the museum at Ottawa, but in separate museums in each province. These collections, to be of the greatest value, should be accessible to the students of geology in the different universities, who would thereby be stimulated to devote more time and energy to the stratigraphical side of their work.

It is hoped that these remarks may serve to direct the attention of the members to the great importance of stratigraphical work, and to remove the impression that palaeontology and chronological geology are foreign to the mining engineer. In fact, the writer would like to emphasize the point that these subjects, if not so immediate, are none the less fully as "economic" as those branches to which such a large percentage of Canadian geologists and mining engineers are directing their undivided attention.

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DISCUSSION.

MR. CRAIG—Might I ask what are the prospects of getting coal north of the height of land in Ontario?

DR. PARKS—As I have tried to say, we do not even know if there are any carboniferous rocks in Ontario. We know that there are some Silurian and probably some Devonian, but there is no evidence that there are carboniferous rocks, although it would be premature to say that there are not.

PROF. MILLER—Our President, Mr. Coste, is certainly the greatest economic stratigraphical geologist we have. Most of us know that Mr. Coste discovered the two main gas districts in Ontario. He has given a great deal of time to the study of this branch of geology, and if he were here I am sure he would emphasize what Dr. Parks has said as to the economic value of this subject. A great many people have the idea that the study of fossils is of little economic importance, but Dr. Parks has shown us that it is of very great importance indeed. There are one or two points in this connection to which I might refer. Most of you

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have noticed that there has been a discussion going on in the newspapers in the county of Lambton during the last two or three weeks regarding the importation of crude oil into Ontario. Some oil men in the district wish to import this crude oil in order to keep their refineries running, as they claim that they cannot get enough at home. Other refiners wish to have an import duty on oil. It is claimed by one party that if more drilling were done in old Ontario, more oil would be found. I think that contention is quite true. I have had occasion recently to look into some recent oil discoveries in the older portion of the province. One of these discoveries is near the border line of Kent and Essex. There, oil has been found in the Guelph formation which is much lower than that in which oil has heretofore been found in productive quantities. It looks as if there might be quite an important supply of oil several hundred feet below the old Corniferous horizon. In Brant county they have also recently found some wells which give considerable promise. The wells are, I believe, in the Medina, which is again several hundred feet below the Guelph, which in turn is one thousand feet below the Corniferous. It is very important that we should have the distribution of these formations determined in this province. The most complete literature we have is contained in the Geology of Canada, published in 1863, which, of course, is not up to date. I have had occasion to look up information during the present winter, and that publication contains about the only information I could get, prepared in a systematic manner. The northern James Bay slope is also very important. Dr. Robert Bell tells us that the Corniferous formation in that part of the province occupies a much larger area than the whole of the southwestern peninsula of older Ontario. Occupying such a large area there, we may expect with confidence that important deposits of oil and gas will be found in that far northern region, when it is made accessible by railways. I agree with Dr. Parks that stratigraphical geology in this province is as important as that of Archean geology.

MR. INGALL—There is a point about that gas and oil which is important to us on the Geological Survey. The mining section has been supposed to get as many of these boring records as

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possible and for years we sent bottles to those who said they would send their records, but in most cases they failed to do so. The checking of the record as given by the driller means a great deal of work, and it is not always as correct or detailed as required. There are thousands of these borings the record of which have been lost forever, and upon the careful collections of these records rests the only hope we have of working out the anticlines and synclines upon which the distribution of the storage reservoirs of oil and gas depend. Of course, the mining section of the Geological Survey cannot spread itself over the whole Dominion, and consequently we can only look after the matter in a superficial way. This is perhaps a good opportunity to point out that there is an immense amount of valuable information lost every year in this way. Seeing that the Geological Survey has so many things to attend to, and such a large territory to cover, perhaps the Provincial Mining Bureau would tackle that important question.

PROF. MILLER—I am afraid that the Provincial Mining Bureau has its hands pretty full now. We go one week to the nickel region; another week is devoted to the limestone; another to the oil region, and so on.

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Journal of the Canadian Mining Institute, Vol. VII.

SOME RECENT ROCK MOVEMENTS IN THE LAURENTIAN AND HURONIAN AREAS.

By S. Dillon Mills, Toronto, Ont.

Toronto Meeting, March, 1904.

As our ordinary life experience and the records of mining developments from the earliest known works down to the present day, show the earth's crust to be practically in a position of stability, there has arisen naturally an idea that the period of instability has long past away, and that since the glacial period, at all events, no movements other than those of volcanic origin have taken place. At least, this used, to a great extent, to be my own attitude of thought on the subject, and I have no doubt that others would agree with it; but since I commenced the study of the Laurentian and Huronian districts of Ontario some years ago, a contrary conviction has been gradually forcing itself upon me as regards even these apparently most solid areas of the earth's surface. With the idea that, in looking upon glacial action and atmospheric erosion as the only formative agents in the shaping of the picturesque features in the wilder districts of our land (where so many of our citizens go yearly to enjoy the varied scenery and to cast off for a brief period some of our city-made civilization, the white man's burden) we have been laying upon the icebergs and glaciers of the past a load sufficient to reduce them to a condition of harmless quiescence. I may here remark that I believe we should, in case of our Canadian archaic areas, make a distinction between the glacial period, when this and other parts of the now habitable earth were covered by immense quantities of ice thousands of feet in thickness, according to some authorities, when there could be in these districts, owing to absence of elevation, no motion and no erosion; and that period when were produced those glaciated surfaces and striæ, with which we are all so familiar. The period when these were produced must have been one of submergence in flowing waters, with tides or currents

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bearing ice floes laden with gravel and boulders, and with seasons of warmth, when the grounded ice melted, and deposited its load; possessing in fact a climate but little different from, and conditions very similar to, those now existing in the Georgian Bay but with perhaps stronger currents. If the Georgian Bay Islands were subject to the strong currents, which have left their mark, in the shape of sand bars and boulder-strewn gravel-reefs, high above some of the fertile farm lands of Central Algoma, they would show much greater evidence of recent glacial action than they do today, if, indeed, any remained to tell the tale.

As mining engineers we are not specially interested in picturesque scenery, but the few facts to which I wish to call your attention may be found to have some interest in connection with the condition of the country, rocks, location of shafts, etc. It is by attention to little things that we arrive at knowledge.

To save time I will limit myself to observations made recently at two points. The first in Haliburton County, Ont., the second in Gladstone and Patton townships, Algoma.

In that portion of Haliburton County, near Wilberforce station, on the Irondale, Bancroft & Ottawa R.R., one of the most picturesque features of the scenery is Lake Farquhar, which is bounded on the south by a rocky ridge of considerable height, broken by peculiarly formed rocky ravines which have their eastward or south-eastward sides precipitous, in some places perpendicular, from 100 to 150 feet in height, while the westerly sides are gentle slopes of 15 to 20 degrees. The rock on the summit of the steep side is rounded by glacial action, but not the edge of the cliffs; near the bottom of the gentle slope on the opposite side, the rocks show indications of the same action, but I do not think the valleys can have been formed in this manner for the following reasons: First, the shape of the valley could not be explained on the glacial theory except by a difference in the hardness of the rocks; now, in some places there is no difference in resisting quality and in some places the soft rock is at the summit. Secondly, the absence of indications of glacial action on the faces of the steep cliffs might be accounted for by supposing the glaciated face to have fallen in consequence of weathering, and the point must be

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conceded in places where there is much talus at the foot of the cliff, but in some places there is none. Thirdly, that at the bottom of one valley wider than the rest there are three hogbacked ridges of gneiss, shaped evidently by glacial action, running not lengthwise, but across the valley, one of them running almost to the base of the cliff; looking as if they had been furrowed out while in a position higher than the present summit, and had then dropped by a gradual movement, or series of movements, to their present position. The evidences of these movements are abundant. There are indications of at least four different outlets from Lake Farquhar, each at very different levels, one of them terminating in a beautifully rounded pot hole about 12 feet in diameter by 8 feet deep, situated on the south side of the rocky ridge probably 90 feet above the present outlet.

In view of these facts we seem driven to one of two conclusions: First, that the rock movements which formed these ravines took place prior to the glacial era, that the ravines were filled with solid ice, so protecting from glaciation all but the summits of the ridge, till, towards the end of the ice age, when this anchor ice moved out, grinding out the bottoms of the ravines as it went, at the same time gradually lowering the outlets from place to place. But this does not appear satisfactory in view of the great length of time during which the level must have remained stationary in order to allow of the great wearing action which has taken place at each separate outlet; the direction of the "hog-back" of gneiss above mentioned also is against this explanation. There remains then only the original supposition, namely, that the changes of level have occurred since the glacial period, this view receiving additional support from the fact that the sandbar formed by the current from the outlet which preceded the present one, is still visible in the alluvium to the south of the ridge, that outlet being now about 30 feet above the present natural lake level.

There are numerous exposures of Laurentian crystalline limestone in some parts of this neighborhood which have by their gradual weathering caused many changes in the appearance of the scene, but the ridge through which the ravines pass, consists of

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a medley of gabbro, pyroxenite, gneiss and intrusive binary granite, limestone being found only in one place on the outer or south side of the ridge.

Turning now to observations made in Algoma, in the Huronian of Gladstone and Patten townships, some time after my first visit to Lake Farquhar, I was sent to Gladstone township to report on some development there in progress on a copper property near Iron Bridge P.O. and found part of the work to consist of a shaft 8 x 12, then about 45 feet deep, sunk on the south flank of a rocky knoll near the upper end of a small sloping ravine extending up the side of the main ridge, which rose in places probably 250 feet above the farming lands on the southwest; the east and west ends and north side of the shaft were in good solid rock, but the south side was completely shaken up; the shaft had been sunk on a lead of quartz carrying a fair amount of chalcopyrite, the lead was very irregular, without partings, being frozen to the rock on both sides. Both it and the country rock, an intrusive syenite, showed evidence of secondary movement in small fissures filled with secondary quartz formation carrying a little chalcopyrite occasionally, but the shaken condition of the south wall was evidently caused by a still later movement, as the seams remained uncemented except by a little limey matter in places. No evidence of this movement could now be seen at the surface as the rock at that side was completely covered by the dump. Had this rock been properly examined in the first place by anyone who understood these rock movements, the shaft would never have been sunk in this place, and a loss of $1,500 would have been avoided. East and west of the shaft a dense growth of underbrush extended for some distance, with a few large trees. To the north about 40 feet from the shaft rose a perpendicular face of rock 15 to 20 feet in height, the top of this rock had the ordinary rounded appearance of these glaciated hill tops, and extended between 20 and 30 yards northward, then dropping at a slope of about 45 degrees to a sloping wet swale about 80 feet below. To the westward it extended probably 150 yards, then dropping perpendicularly about 90 feet, to a sandy ridge heavily timbered, which stretched westward for some distance, bounded on the north by the swale above

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noted, and sloping south to the general level of the cleared land. The shoulder of rock on which the shaft was located presented somewhat the appearance of the slips so common in tidal harbors, forming a sloping causeway; it dipped down westward beside the wall of the upper bluff till it reached the level of the sandy ridge, but it was covered mostly with earth and debris from above. Where the rock was exposed it showed the same glaciated appearance as the upper rock, and was full of small stringers of quartz with traces of chalcopyrite running parallel to the bluff wall, east and west approximately. The dense growth of leafy underbrush and the presence of the earth over most of the rock prevented my gaining any further knowledge as to the rock structure at that time, but, having occasion to visit the place early in the spring following, I made a further examination of the matter, and found that nature had assisted me in an unexpected manner. A few yards west of the side of the shaft a large pine tree of probably 60 years' growth had been blown down, lifting a great mass of earth in its matted roots, laying bare the rock beneath and showing a sharp edged step down about three feet in depth at the bottom of which was another glaciated surface similar to the upper one. The cleavage had taken place along a stringer of quartz parallel to the upper bluff, in some spots the quartz had remained adhering to the face of the step, in others it had gone down with the lower rock, there were indications of a further drop outside this, but the depth of earth was too great to admit of examining it, without an expenditure of much time and labor.

Shortly after this, while walking along through the bush to the southwest of the shaft, near the lower end of the little ravine, I came upon an exposure of reddish felsite rock, showing a line of sharp fracture running nearly north and south. A little examination showed that it ran for a considerable distance in this direction, and detached masses along its face (the edges of which were as sharp as if broken quite recently, some of the fragments having dropped 18 inches, some more), showed that here also had been a rock movement coincident probably with the other. The upper surface of the rock in situ, and of the detached portions, was beautifully smoothed by glacial action, and the position

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of the fragments showed that there had been no lateral motion, (by a sufficient lifting power they could have been fitted again to the places from which they had dropped). The accumulation of earth and debris prevented the total drop being ascertained, but it may have been anything over 10 feet. In this district we have, therefore, evidences of four different periods of action which have combined to give the present surface configuration.

First—That in which a series of fractures occurred producing gradually the disconnected rents and chasms running nearly east and west which were then filled with quartz, calespar, siderite, etc., with chalcopyrite.

Second—Another period of dislocation causing the secondary formation of stringers or small veins already noted, and a movement of greater extent along lines running north and south so that the veins cannot be traced beyond these faults in some cases. This latter north and south dislocation may have been later than the east and west one, this I have not yet been able to determine, but it was prior to the glaciation period, and to it the country owes its most striking feature in the way of cliffs and ravines. The results differ from those in the Farquhar district in that the cliffs are on the west side of the north and south ravines instead of on the east and the upper edges where not changed by falls of rock occasioned by frost cleavages, etc., show the glacial rounding very distinctly. In tracing the course of one vein, I came to a spot on the lower shoulder of a cliff, overhanging a ravine, where the alluvial matter and the rocks debris had formed a slope up to, and over, the edge of the lower cliff. On removing the upper part of this I found a vein, consisting here of calcite and siderite chiefly, about three feet wide, showing a beautifully rounded shoulder on the edge of the concealed cliff, which here showed, so far down as I was able to have it exposed, a smooth glaciated perpendicular face, and beyond this point the vein could not be traced with any certainty (though another vein occurs about 400 yards to the eastward and about 150 yards north of the true line), till it reappears about 1½ miles to the eastward on the same line. If this property is ever developed, it will be an interesting point

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to decide if there has been any lateral motion in this case, or only a downward drop of an area about half a mile in width.

Third.—This period is the glacial era when the rugged outlines produced during the two or (as the case may be) three previous periods, were rounded off to something approaching their present aspect.

Fourth.—Another period of gradual dislocation which perhaps still continues in operation.

There is here much that is puzzling, yet worthy of protracted investigation, the movements have not been coincident over large extents of territory, the movements in Algoma have, for instance, not coincided with those in Haliburton, while in the intervening Sudbury district there may have been only one movement (this I have not investigated), in fact, in some cases a difference may be found within the limits of a few townships. That this has always been the case is shown by the difference in the type of vein prevailing in different parts of Algoma. At Bruce Mines we have a series of well defined veins curved and twisted in various directions mostly of considerable width with well defined walls carrying a low percentage of copper. In Gladstone and Patton, veins showing dislocating action along east and west lines, traceable for 8 or 10 miles in one straight line with occasional gaps as above noted, carrying a much higher percentage of copper and offering the peculiar feature that while practically continuous and forming parallel lines across the country at various distances apart, the veins at the surface pass from fissure to fissure as if the rending force while acting along the general east and west course had in some places produced fissures slightly diagonal to that course, differing from it by 5 degrees to 10 degrees. The ore deposits in those fissures centre about on the general east and west line, but are too thin and too much elongated to be properly called lenses. Then further east we have the more lense-like formation of the Massey district, while at Sudbury we have a totally different formation as shown by Dr. Coleman in his very interesting report on that district.

The subject is a somewhat difficult one to investigate owing to the impossibility of doing any satisfactory work when there are

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leaves on the underbrush or snow on the ground, so the time available becomes practically limited to an average of a month or six weeks in the year. If these movements had been noticed in a limestone formation, or in a district showing evidence of volcanic agency, or recent subterranean chemical action, I would not have thought it worthy of particular notice, but in the districts spoken of, where all such agencies seem to have been at rest, since the formation of the mineral deposits, it would appear as if something remained yet to be learned in this direction, by those who desire to look more deeply into the workings of nature. Perhaps the new geology with its theory of the subterranean origin of water springs may account for the movements above noticed.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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Journal of the Canadian Mining Institute, Vol. VII.
Student's paper, presented for the Prize Competition.

THE RELATIVE ATTRACTION OF SOME COMMON MINERALS FOR RESIDUUM OIL.

By J. F. Hamilton, School of Practical Science, Toronto, Ont.

Toronto Meeting, March, 1904.

It has been known for several years that there is a certain attraction between oil and some minerals so that these minerals may be picked up and held by the oil while others are not affected. This knowledge led to the evolving of a process by Messrs. Elmore for the separation of certain sulphides from the accompanying gangue.

The process has been described in different journals and magazines and will not be discussed here. The object of the following experiment was to compare the relative attraction between the oil and some of the minerals likely to be affected most by the oil concentration process.

Pure mineral was selected in each case, and every piece was ground to a square block, the smaller ones of one square centimeter area and the larger ones to two square centimeters area, and about .2 to .4 centimeters in thickness. A fine copper wire, number 20 gauge, coiled at one end, was fastened to the upper side of each block of mineral by means of Canada balsam. The balsam was not allowed to project over the sides of the mineral, care being taken to always keep the sides clean. The wire was normal to the lower surface of the mineral so that the whole area might touch the oil, and the pull would be exerted at right angles to the surface of contact. The upper end of the wire was bent in the form of a hook so as to fasten on the beam of the balance.

The balance used was an ordinary pulp balance sensitive to two milligrams. One scale pan was taken off and instead a weight with a ring was attached, to almost balance the other scale pan. The copper wire bearing the mineral to be tested was hooked on this ring and while the mineral was immersed in water just sufficient weight was placed on the pan to bring to a balance.

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The oil used was the ordinary thick residuum oil. Mr. Forbes, while making some arrangements with it last year, found the specific gravity to be 0.925 and the viscosity 12241 at 65 degrees Fahrenheit. The temperature of the oil and the water was kept at 60 degrees Fahrenheit, that being about the temperature of the room in which the experiment was carried on.

The oil was put into a tin dish to the depth of one-half an inch and the surface made even, then the water was poured in to the depth of about one-half an inch. This dish was placed under the suspended mineral so that the mineral was in the water when the opposite scale pan was down and the beam of the balance raised in position for weighing. As the beam was lowered the mineral came down to the oil, lowering sufficiently for the whole weight of the mineral and wire to rest on the oil. After many trials it was decided to allow the mineral five seconds rest in the oil, and sufficient weights were put on the other pan to pull the mineral out of the oil in about three seconds. At the end of time of rest, the beam was raised, and this lifted the pan with the required weights on, thereby exerting a given pull on the mineral in the oil. The time required to pull the mineral out was registered by a stop-watch.

The pieces of the mineral were cleansed of the oil and rubbed after each experiment, so that water would wet the surface before being used again. Each piece of mineral, with wire attached, was made to weigh the same in water, so that the specific gravity of the mineral did not affect the experiment in the least. The weight of the specimens of one square centimeter area was 2.53 grams. The weight of the larger specimens of two square centimeters area was 3.49 grams, both sizes being weighed while in the water. Twenty to forty tests were carried out with each specimen and the average time taken, although any given time of pull did not vary much from the average.

The accompanying tables, 1 and 2, showing the weight used and the average time required, give a very accurate idea of the relative adhesive qualities of the different minerals tested. The oil readily adhered to most of the sulphides, sticking all over the lower surface, and was lifted up by each piece. The quartz did

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not adhere to the same extent, but would pull away quite clean, except just a little oil sticking to the corners sometimes.

Mineral.	TABLE I.				TABLE II.			
	Size. Sq. C. M.	Time of Rest, Seconds.	Weight Used, Grams.	Result, Average Time, Seconds.	Size. Sq. C. M.	Time of Rest, Seconds.	Weight Used, Grams.	Result, Average Time, Seconds.
Pyrrhotite.....	1	5	3	3.1	2	5	6	1.95
Pyrite.....	1	5	3	3.25	2	5	6	2.2
Mispickel	1	5		2.6	2	5	6	1.8
Chalcopyrite	1	5	3	2.9	2	5	6	2.3
Grey Copper	1	5	3	2.8	2	5	5	2.7
Galena.....	1	5	3	2.6	2	5	5	2.7
Zinc Blende	1	5	3	2.9	2	5	5	2.5
Quartz.....	1	5	2.3	3.3	2	5	4	2.1
Mica Schist	..	..	2.1	2.2	2	5	3	1.9
Calcite (pink)....	..	..	3	2.2				
Calcite (clear) ...	..	..	2	3.7				
Hematite.....	..	..	3	3.25				
Magnetite	..	..	3	3.2				

Two specimens of calcite were used, one of pinkish color and the other a clear cleavable mass. The colored one seemed to adhere more to the oil, as some of the latter would be brought up on the specimens each time, while the clear piece pulled away quite clean, like the quartz. The mica schist which was tried had even less attraction for the oil than either calcite or quartz, as it would separate almost immediately, never bringing any of the oil up with it.

Those of the sulphides which show a shorter time and a lighter weight did not adhere as well as the others, but stuck to the oil only in parts. Noticeable cases were the two specimens of zinc blende. The larger piece was darker than the smaller one and did not adhere nearly so strongly, as will be seen from the tables. The hematite and magnetite tested adhered as well to the oil as did the sulphides, never once pulling away without bringing oil with them.

The results cannot be taken as giving the absolute pull required per unit area to draw the mineral from the oil, because,

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as can be seen from the tables, the specimens of two square centimeters area did not require twice as much as did those of one square centimeter area. Some smaller pieces were also tested, but they showed still greater pull per unit area than those of one square centimeter area. Also, the temperature of the oil will vary the pull required, so that the results only claim to show the relative attraction of the different minerals for residuum oil.

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DISCUSSION.

PROF. PORTER—I believe that scientific investigation on the adhesion of oils to minerals is very much needed, and Mr. Hamilton has worked it out in a way which I believe should yield very valuable results. I am very much interested in what he has done, and I hope that these experiments may be carried even further. There seems to be a little difference between his method and the actual operation that takes place in the ordinary oil separation process. I should think that a study of the matter, just as he is studying it, would be of extreme value in the practical process of oil separation. He has done a great deal of very useful work on this subject.

PROF. KIRKPATRICK—Do these results occur in practice?

MR. HAMILTON—In practice pyrite, pyrrhotite and chalcopyrite have been found to give the best results, at least when only mixed with gangue matter. I believe that the best results have been obtained from these minerals. Zinc blende is in second place, but it was behind the former minerals in actual practice. I also think that the results differ somewhat in proportion to the kind of gangue matter that goes along with these minerals. In actual practice the amount of oil per ton of ore varies also the separation. I think that a greater quantity of oil mixed in with the ore would give a greater time of contact between the minerals and the gangue matter and the oil. We found in our experiment that the longer the time of contact it took the greater time it took to draw the minerals away from the oil, it was the case

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even with quartz and calcite. If the gangue matter adhered almost as well as any of these minerals it would be a very difficult matter to make the separation by this process.

MR. MILLS—When experiments are made on minerals of the same character from different localities are the results the same? There are differences in the particular results which are not accounted for by chemical action. In the case of iron ore I found great differences in the manner in which the ore breaks up, independent of its chemical composition and this affects its action in the furnace. I wrote an article on this subject eighteen years ago for the *Charcoal and Iron Workers' Journal.*

PROF. MICKLE—That point was touched on in the paper. Two varieties of zinc blende were used, one almost straw colored, and that exercised apparently as great an attraction for the oil as any of the other sulphides; whereas the dark zinc blende had a much smaller attraction. I have noticed that the results of previous tests generally show that zinc blende is not so easily separated at the other sulphides, but I think in those cases they must have been experimenting with the black zinc blende. It will be noticed also that in the case of the calcite the surprising thing was that the pink calcite had quite a considerable attraction, whereas the clear pure calcite acted just like quartz.

MR. MILLS—That is not exactly the point, because in these cases there is a marked difference in the chemical composition.

DR. WALKER—Calcite, galena and mispickel and some others have similar physical characteristics, while the quartz and pyrites and others that have practically no cleavage have different properties altogether. I do not know whether that would have something to do with it.

PROF. MICKLE—I scarcely think that would hold, because the specimens experimented on were both the same mineral, viz., zinc blende.

DR. WALKER—My remark has reference to the smoothness of the surface.

MR. HAMILTON—The specimens were all ground with the same sized emery and the same plate, and should have a similar surface.

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DR. WALKER—It seems to me that you could only get uniform results if you were to grind until your surfaces were perfect reflectors.

MR. HAMILTON—Take the hematite; it seems to be as smooth as any specimen we had, and we found that it adhered as well as any one of the sulphides. These illustrations are all from specimens of an area of one square centimetre.

DR. PORTER—In answer to the question asked by Dr. Walker, I think I can say that the table as shown by Mr. Hamilton, does not agree in the order of adhesion or difficulty of withdrawing the specimens in several respects, with the results in practice as I understand them, nor with laboratory experiments as they have been made under my charge. Of course commercial ore separation must be upon occurrences which have a natural surface and whether the difference is due or not to the manner of preparing the specimens I am not prepared to say. But there is a very marked difference in practice in the adhesion of quartz and chalcopyrite, whereas here you see that the quartz adhesion is greater rather than less.

PROF. MICKLE—The weight is smaller. On all the sulphides the same weight was used, they were given the same weight test.

DR. PORTER—My experience is that quartz does not free itself from oil as readily as the calcite. Which was the zinc blende that gave the same figure as the chalcopyrite?

MR. HAMILTON—With exactly the same weight on the opposite scale pan it required 2.9 seconds to pull both the chalcopyrite and the zinc blende away from the oil.

DR. PORTER—Which of the two lots of zinc blende gave these results?

MR. HAMILTON—The lighter colored zinc blende gave these results; the dark required a much shorter time. Although the quarts shows 3.3 seconds with a weight of only 2.3 grams, when the three grams weight was put on, the same as for chalcopyrite. it pulled away almost immediately; the time required was too short to measure it even with a stop watch. Very little variation in the weight seems to make quite a difference in the variations of time,

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so that we could only determine the time in this case with a light pull or weight.

DR. PORTER—Mr. Hamilton's answer fully disposes of the criticisms I proposed to make.

PROF. KIRKPATRICK—As I understand the practice, chalcopyrite can generally be removed from pyrite by proper manipulation of the oil, for some reason or other, the former seems to have a very strong adhesion to oil. Perhaps the question as to the prepared surface may account for the discrepancy.

MR. HAMILTON—We could not find the difference between the adhesive qualities of pyrite and chalcopyrite.

DR. ADAMS—I would ask whether Mr. Hamilton does not consider that in actual practice there probably would be a greater difference between mispickel and pyrite than is shown by the use of this large surface in his tests. In actual practice of separation the particles used would have a very considerably smaller surface area, and one would suppose that there would be a greater diversity than shown by these figures. Would this not represent a minimum rather than a maximum difference?

MR. HAMILTON—I should think, however, from our experiments that there would be a greater difference between the adhesive qualities of the different minerals if the particles were smaller, because we always obtained a greater difference as we reduced the size of the particles.

PROF. MICKLE—The most interesting thing is the way in which these two metallic oxides acted. I had an idea that it was only the sulphides and the metals that were attracted by the oil, but some hematites and magnetites at any rate are attracted. I have tried corundum and that oxide is not attracted in any way.

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Journal of the Canadian Mining Institute, Vol. VII.
Student's paper, presented for the Prize Competition.

RATE OF SOLUTION OF GOLD IN POTASSIUM CYANIDE.

By T. H. Plunkett, School of Practical Science, Toronto, Ont.

Toronto Meeting, March, 1904.

Authorities on the use of the cyanide process as an extractor of gold from its ores, while being unanimous in the opinion that potassium cyanide can only be used on fine gold, have made few attempts to define the exact limits of fine and coarse gold. These terms, fine and coarse gold, so commonly used in discussing the merits of the several methods of gold extraction, are very indefinite. While authors do not hesitate to assign certain processes of extraction for fine, and others for coarse gold, no one seems to have endeavored to find a limit so as to be able to state definitely to what extent certain processes can be used to advantage.

Having had occasion to use this process on different ores, the writer has made several experiments to find what effect cyanide solutions have on particles of gold of varying sizes. This effect varies greatly with the manner in which the solution is applied. Estner made it clear that oxygen was an essential element to enable the potassium cyanide to do its work. It has also been suggested, by recent writers, that temperature played a part in the extraction.

With these points in view, the writer has treated the gold in three ways. First, by allowing the solution to percolate about the gold. The gold bead was placed in a porcelain dish containing the solution and the latter was drawn off at intervals of an hour or two to enable it to absorb oxygen from the air. Second, air was made to bubble through the solution while in contact with the gold. Third, the solution, with air passing through it, was heated to about one hundred degrees Fahrenheit.

In preparing the gold particles a known weight of the metal was dissolved in aqua regia and diluted with water to five hundred cubic centimeters. Certain volumes of the solution were then

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taken, and the nitric acid boiled off, after which it was evaporated tc dryness on troughs made of pure lead foil. The lead was then cupelled, leaving beads of gold, spherical in form. These were carefully weighed, and their diameters measured under a microscope.

A three-tenths per cent. cyanide solution was used in the following experiments:

RESULTS OF EXPERIMENTS.

Weight of Bead	Average Diameter	Process	Time	Weight Dissolved
.800 mg.	.455 mm.	Percolation	16½ hours	.040 mg.
.800 "	.455 "	Agitation	16½ "	.180 "
.800 "	.455 "	Agitation and Heat	16½ "	.250 "
.300 "	.299 "	Percolation	7 "	.007 "
.300 "	.299 "	Agitation	7 "	.080 "
.300 "	.299 "	Agitation and Heat	7 "	.100 "
.170 "	.260 "	Percolation	3 days	.100 "
.170 "	.260 "	Agitation	16 hours	.070 "
.170 "	.260 "	Agitation and Heat	7½ "	.080 "
.130 "	.247 "	Percolation	3 days	.080 "
.130 "	.247 "	Agitation	20 hours	.130 "
.130 "	.247 "	Agitation and Heat	16 "	.130 "
.110 "	.208 "	Agitation	16 "	.060 "
.110 "	.208 "	Agitation and Heat	7½ "	.060 "
.100 "	.201 "	Percolation	3 days	.088 "
.100 "	.201 "	Agitation	16 hours	.070 "
.100 "	.201 "	Agitation and Heat	12 "	.100 "
.070 "	.195 "	Percolation	3 days	.070 "
.070 "	.195 "	Agitation	16 hours	.070 "
.070 "	.195 "	Agitation and Heat	10 "	.070 "

From these results it would seem that agitation and agitation aided by heat have a decided advantage over the percolation process, while agitation aided by heat has a less decided advantage over agitation alone. To obtain an extraction in a reasonable time, beads of about .100 m.grams in weight, with an average diameter of .201 mm. seem to be the maximum size.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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DISCUSSION.

MR. THOMPSON—I have listened to this paper with very great pleasure, because during the past year and a half I have been endeavoring to get a cyanide process for the treatment of heavy sulphide ores, and I have done a great deal of work with what is now known generally as the Hendryx process. While discussing Mr. Kirby's paper I mentioned the gold value in pyrrhotite on the easterly end of the Rossland veins. I should have said then that the gold values throughout this pyrrhotite were unevenly distributed, and of four thousand samples taken from last July up to the first of December, carefully assayed in duplicate, 50 per cent. of those samples ran anywhere from $1.00 as high as $400 per ton. The samples were all taken carefully and it was not at all an uncommon thing to find samples taken across the vein within a foot of each other in apparently the same material, varying from a trace to one hundred dollars. The conclusion I came to was that throughout the pyrrhotite there was considerable coarse gold, and that the gold values were very unevenly distributed. This was shown further when we tried to work out the reduction of these ores by means of potassium cyanide solutions. The Hendryx process may not be familiar to you all and I will give you a very brief description of it.

Dr. Hendryx has patented an agitator which consists of a tank varying in diameter from 8 to 20 feet. In the centre of this tank he puts a pipe going down near to the bottom of the tank. In this tank he has a series of paddles revolving in such a manner as to cause the sands in solution to rise upwards, and at the top of the tank there is an apron over which the pulp is spread and dropped down on the side of the tank again. There is constantly a stream of pulp solution flowing over and completing the process. He also operates by means of electrolysis in the same agitator. We found by crushing the ore to 60 mesh we could get fairly good results in from six to eight hours. We also found exactly what the author of this paper found, that we required to raise the temperature of the solution within the agitator; normal temperatures would not bring about good results in a given

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time. Therefore, it was necessary to heat the solutions and keep them at a temperature ranging from 75 to 85 degrees F. during the agitation. After carrying on various experiments the best extraction we could get was from 70 to 75 per cent. We, therefore, tried another scheme, to take the ore and carry out amalgam tests and then cyanide the tailings, and I was surprised to find that the total extraction by this method immediately jumped from 75 to 90 per cent. I attribute this to the fact that there were coarse particles of gold throughout the pyrrhoite, and that it was saved by amalgamation, and the finer particles of gold were left in the tailings to be treated by the cyanide. I am sorry I did not bring my complete returns with me so as to show you the relationship and the various recoveries of the gold by amalgam and then by cyanidization. If my memory serves me, I think we recovered 25 per cent. of the gold by amalgam and the balance in the cyanide plants. Dr. Hendryx has started a mill in the Republic Camp, in Washington, which I am watching with a great deal of interest and I am hoping to be able to carry on these experiments on a much more extensive scale in future. I feet quite satisfied that we shall eventually be able to get a cyanide process that will extract the gold with a reasonable saving and a reasonable expense, from pyrrhotite such as we have in the Rossland camp. The main points at issue appear to be that the time of contact with the solution was not sufficiently long to dissolve the coarse particles of gold, and, therefore, the ore will require a preliminary treatment in an amalgamator. I believe that the method of agitation adopted by Dr. Hendryx and the heating of the solutions will bring about a satisfactory result. On the Mountain Lion ores the experimental work shows an extraction of 96 per cent. of the gold in six hours. I think this company have tried the ordinary percolation and agitation process in their mill without success. They are now putting in this agitator, and assisted by a steam boiler, and probably with some assistance rendered by the electro-chemical branch they are hoping to make recoveries sufficient to warrant them in installing a very extensive plant. I am quite satisfied that next year you will have some very interesting papers on this process, because a great many of

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our western miners are taking the matter up and are paying a great deal of attention to it. I must congratulate the author of the paper upon carrying out these experiments so carefully, and I congratulate the Institute on being able to get such valuable information from our student members.

MR. MILLS—Please explain how they manage to get the current on the slope of the table.

MR. THOMPSON—The plates are within the agitator itself, and are placed so as to prevent the scouring action of the cyanides. Various plates have been used, but the one recently adopted is simply a plate composed of thin corrugated metal; the entry of the sides being filled with a preparation of carbon so that the gold can be easily extracted by simply knocking out a little piece of carbon. The plates are now being patented so that I cannot go into details, but they will be available in the course of two months. They use a current of about 1½ amperes and from ¾ to 1½ volts; the current being generated by means of a motor. There is one little difficulty in regard to that, and it is this, that complete precipitation of the gold does not occur. I found that in my solution I had from 40 cents to a dollar and it seemed impossible to precipitate that particular value from the solution. The problem is now to find the means of precipitating the fine gold. Dr. Hendryx is very enthusiastic over his process and he believes that this problem is solved. When we speak of extraction in that case I have made no allowance for the gold left in the solution.

DR. PORTER—Mr. Thompson mentioned the maximum amperage and voltage used; is that per square yard of plate?

MR. THOMPSON—That is for the whole set of plates.

DR. PORTER—It is rather interesting to know the approximate amperage by the square foot, and if I am not asking you to disclose a secret I would ask approximately the number of square feet.

MR. THOMPSON—I have not worked that out. I am very sorry I have not my tables with me. I am not quite sure just exactly how many square feet of plates were put in.

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DR. PORTER—I assume that there would be a great many square feet and a very small fraction of an ampere per square foot.

MR. THOMPSON—Very small indeed.

DR. PORTER—The fact that the gold remains in solution might not mean that it was lost. This electro process generally keeps the solution in fairly good order. Would you not find after the solution had gone around once or twice that it would accumulate as much gold as it was going to carry? I should think there would be no serious loss on account of the inadequateness of the precipitation, because you are using the same liquid over and over again.

MR. THOMPSON—Yes. I omitted to say that after the solutions have gone through the first time the solution will carry its gold value, and after the second time there is no loss. I would like, however, to get the entire gold out of the solution. Where you are working in camps where there is only 50 cents a ton profit every cent a ton means a great deal to us; in some places we cannot hope for any greater profit than 75 cents a ton and we have to figure very closely.

PROF. MICKLE—Has Mr. Thompson made any attempt to determine the size of the gold which refuses to dissolve?

MR. THOMPSON—No. As a matter of fact I am only speaking problematically, because we have never been able to find the free gold, although we have made a good many experiments looking for it. In the lower workings of the Le Roi No. 2 they have been able, I understand, to locate free gold, but the gold values are apparently so low and the pyrrhotite yields such an enormous amount of concentrates that it seems to be impossible to hand-pan them and get a showing of free gold in the particular ore I have described.

PROF. MICKLE—Could you not dissolve the sulphides out with acids?

MR. THOMPSON—Yes, we might do it in that way, but we are much more interested in the commercial results than in the scientific.

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PROF. MICKLE—The discussion has brought out very clearly that it is very difficult to secure an ore in which all the gold is suitable for extraction by the cyanide process. From the result of these experiments it will be seen that if you use the ordinary method without agitation or heat, it takes a particle of gold only .2 of a millimeter three days to dissolve. If you hunt for ores you will find it difficult to get an ore in which all the gold is as small as that, and of course the larger particles will not be dissolved and the extraction will be poor.

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Journal of the Canadian Mining Institute, Vol. VII.
Student's paper, presented for the Prize Competition.

TREATMENT OF THE DRY ORES OF THE SLOCAN.

By T. W. Cavers, School of Mining, Kingston, Ont.

Toronto Meeting, March, 1904.

In the Slocan district of British Columbia occur large deposits of silver ore of two types, the so-called "wet" and "dry," but only one, the latter, is discussed in this paper.

These "dry" ores, occurring as quartz veins in the granite, which is the country rock, are composed of argentite and a little pyrite, and there is reason to suspect the presence of cerargyrite and ruby silver ore.

From an examination of a thin section, under the microscope, the quartz was found to be very much broken up; the values, chiefly as silver sulphide, were scattered in very fine grains in the interstices between the larger pieces of quartz; and the cementing material was silica, so that, apparently, the large grains of quartz represent the original mass, which had been extensively fractured, and the silver sulphide was deposited afterwards along with silica in the spaces.

At present this ore is being treated by the smelters, but the miners complain that the smelter rates are exhorbitant and even ruinous, and they are looking either for a reduction of the rates or for some other method of treatment which would give them better value for their ore.

It is, however, not a case of too high smelter rates, but of too low grade ore to be treated by smelting. As it now stands, a large proportion of medium grade ore is discarded, to get a product which gives very small returns for the money and labor expended, as it has to bear the cost of mining that which is thrown away. What is therefore necessary is some leaching or concentration process which would give a fair extraction and would either treat all of the ore as mined or the waste material from the hand sorting.

There are very many methods of treating silver ores, and the

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treatment varies widely with the country and the class of ore. In Mexico, for instance, ores similar to those of the Slocan are treated successfully by such amalgamation processes as the Fondon and Krohnke, but owing to difference in climatic conditions and cost of labor these processes could not be applied in British Columbia. Besides, experiments have shown that the amalgamation of silver is too low and the loss of mercury by flouring too high to render them applicable.

Other possible methods are water concentration, oil concentration, cyaniding and treatment with sodium hyposulphite. Of all these, the water concentration proved the most unsatisfactory, the extraction being so low that this method is entirely out of the question. The results from the other processes were more encouraging, but in the limited time exhaustive experiments could not be made. In so far as they go they, however, would lead one to believe that this ore can be profitably treated by a combination of oil concentration and cyanidation.

The ore used in the following tests, except number 4, came from the Republic mine in the Slocan, and is a typical "dry" ore of the district. It assays as follows:

Silver,	28.02	ozs. to the ton at	56c. per oz.....	$15 69
Gold	.115	" " " " "	$20.00 "	2 30
				$17 99

CYANIDING.

Sample Number	Mesh	Roast or Raw	Per Cent. Na CL	Strength KCN	Assay of Sample		Extraction		Per Cent. Extraction	
					Ag. Ozs.	Au. Ozs.	Ag. Ozs.	Au. Ozs.	Ag	Au.
1	40	Raw	....	.25	28.02	.115	7.8	Comb'd	28 combined	
2	100	"	....	.25	28.02	.115	10.2	"	36 combined	
3	40	"	....	.25	28.02	.115	11.7	"	42 combined	
4	40	"	....	.50	17.17	.37	10.24	.27	57.5	73.
5	100	"	....	.25	28.02	.115	11.75	.025	....	....
5 bis	....	.....	....	.....	.....	.....	10.44	.022	37.2	20.
6	40	"	....	.50	28.02	.115	10.45	.05	37.2	44.
?7	40	"	....	.50	17.52 / 28.02	.110 / .115	.56 / .1	.00	.3	....
8	100	"	....	.50	28.02	.115	13.015	.035	47.	30.
9	20	Ro'st	2.	.25	28.02	.115	12 combined		43 combined	

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Referring to the preceding table, numbers 1 and 2 were bottle tests; the others, tests made in glass vessels in which the pulp was agitated by means of mechanical stirrers. Time of agitation, 12-15 hours.

From the results of these experiments, it may be noted that extraction varies with the ore, the fineness to which it is ground and the strength of the cyanide solution.

The ore used in number 4 was a similar character as that from the Republic, but it was a sample from another mine, and the results in the table show that this ore is more successfully treated by this process than the Republic ore.

Number 5 is result of cyaniding the tailings after oil concentration in which one-ninth of the material went into "heads." The assay of the values extracted by cyanide is consequently high, and eight-ninths of the apparent assay must be taken as correct for the percentage of values in the ore extracted. These are the figures on the line 5 bis.

Number 7 determined that no further extraction could be made on tailings from number 6 by the addition of more KCN. The maximum extraction on 40 mesh ore in most cases seems to be 37 per cent., although number 3 shows as high as 42 per cent.

High extraction is attained in number 8 by means of fine crushing, 100 mesh. This in itself has no distinct advantage over number 5, for the extra 10 per cent. values would no more than pay for extra grinding, but in the consideration of the oil concentration in connection with cyaniding, it may be necessary to grind the ore fine for good oil concentration, in which case we have also the advantage of better cyanide extraction due to that fine grinding.

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SODIUM HYPOSULPHITE METHOD.

Ore agitated with solution of 2% $Na_2 S_2 O_3$ plus 1% $Cu SO_4$. Time, 8-10 hours.

Sample Number	Mesh	Roast or Raw	Per Cent. Na Cl	Assay of Sample	Assay of Sample after Roasting.	Extraction	Per Cent. Extraction
				Ag. and Au. Ozs.	Ag. and Au. Ozs.	Ag. and Au. Ozs.	
10	40	Raw	.....	28.14	.....	7.3	26
11	100	"	.....	28.14	.....	8.28	29.4
12	150	"	.....	28.14	.....	9.29	33.
13	40	"	.....	18.1	.....	4.	14. On Original Sample
14	20	Roast	.....	28.14	22.84	8.1	29.
15	20	"	2	28.14	21.95	17.02	60.8

Numbers 10, 11 and 12 showed that extraction varies directly as fineness of crushing. No. 13 was an experiment on tailings from cyanide treatment of sample 6 of the first table, the total extraction by the two methods being 37 per cent. plus 14 per cent. equals 51 per cent.

The use of hyposulphite of soda gives the best results on chloridized roasted ores, since silver chloride is readily attacked by $Na_2 S_2 O_3$ but although the extraction in number 15 was fairly high, the cost of a salt roast would make competition with the smelters an impossibility. However, it is only a question of roasting properly, so as to have little or no loss of Ag Cl by volatilization, and to convert a large proportion of the silver to the chloride, in order to get a high extraction.

AMALGAMATION.

Sample No.	Mesh	Reagents	Assay of Sample		Extraction		Per cent. Extraction
			Ag. Ozs.	Au. Ozs.	Ag. Ozs.	Au. Ozs.	Ag. and Au.
16	20	10% Hg, 1% Na Cl and 3% Cu SO_4	28.14	Comb.	7.6	Comb.	27.
17	100	10% Hg, 100% (hot) $Cu_2 Cl_2$	28.02	.115	2.79	.1	10. 87

The above results demonstrate amalgamation to be impracticable.

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OIL CONCENTRATION.

Sample No.	Mesh	Material	Extraction Ag. Ozs. Au. Ozs.	Concentration Per cent. Total Ore	Per cent. Extraction. Ag. and Au.
18	40	Raw Ore	13.6 Combined	11.	48.3 Combined
19	40	" "	11.985 | .071	11.	42.8 · | 62.
20	.....	Tails from No. 6.....	8.13 Combined	10.	29 in Original Sample

According to number 18, 48 per cent. extraction may be made on the raw ore. In number 20, an extraction of 29 per cent. of the values was made on tails from number 6 (cyanide), in which case 37 per cent. of values were recovered. This makes a total of 29+37=66 per cent.

More interest, however, is attached to the results obtained in test number 19, for on this test, in connection with experiment number 5, are based the claims for successful treatment. The ore was concentrated by oil and the tailings cyanided, and the extraction was 42.8 per cent. silver and 62 per cent. gold in former and 37 per cent. silver and 20 per cent gold in the latter case, making a total of 79.8 per cent. of silver and 82 per cent. of gold values.

Calculating gold to be worth $20.00 and silver 56 cents per ounce, the amounts saved are:

Silver, 79.8% of $15.69.....$12 52
Gold, 82% of $2.30..... 1 88

Total $14 40

$15.69 is the value of silver and $2.30 the value of gold in the original ore.

These results are fairly good, but with proper manipulation even better are quite possible, for in number 18 48 per cent. values are shown to be recovered, whereas 42.8 per cent. only is calculated on in number 19. Whether the extra 5.2 per cent. might be saved or whether it has been recovered subsequently by the cyanidation and 79.8 per cent. is really the maximum extraction cannot be

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stated, but considering that the apparatus used in experimenting was necessarily crude, it can reasonably be expected that with the complete Elmore oil plant and a proper system of cyaniding, an extraction of 85 per cent., or even 90 per cent., of the values would be possible.

Concerning the matter of grinding to 100 mesh, the objection might be raised that the ore could not be leached, and that some expensive system of agitation would be necessary. This, however, is hardly the case, for the oil carries with it the very fine materials which go to make slimes, and which prevent leaching.

The fact that oil concentration precedes cyaniding does not affect the consumption of KCN, since practice shows that all the oil may be removed.

Time does not permit further experiments to determine the best mesh to which the ore should be ground to give the best results, nor to find out how low the consumption of cyanide might be brought. The costs are figured on maximum amount of this salt consumed per ton of ore:

COMPARISON OF COSTS.

Costs of mining, concentrating and cyaniding 1 ton of ore:—		
Mining, etc.		$5 00
Grinding	50c.	
Oil Concentrating	50c.	
		1 00
Cyaniding:		
KCN, 4 lbs. @ .22	=.88	
Zinc, 1 lb. @ .09	=.09	
Labor, Fuel, Lime, etc.	.30	
		1 27
Freight and charges on concentrates (11%) $\frac{11}{100}$ x 12.00		1 32
Total		$8 59

Oil extraction	(No. 19)	11.985	ozs.	silver	and	.071	ozs. gold
KCN "	(No. 5)	10.440	"	"	"	.022	" "
Total "		22.425	"	"	"	.093	" "

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Values recovered by oil, $6.70 in silver and $1.42 in gold		$ 8 12
" " KCN 5.84 " " " .44 " "		6 28
Total "		$14 40

However, as the smelters only allow 95 per cent. of the values, the value of the concentrates is, therefore, $\frac{95}{100}$ of 8.12 = 7.72.

We have then:

Total value recovered	$7.72+$6.28=$14 00	
Total cost of mining and treatment		8 59
Profit per ton of ore mined		$ 5 41

Cost of Smelter Treatment and Preparation of Ore:

In mining ore, as at present for the smelter, it is hand picked, with the result that one ton of high grade material, averaging about $50.00 to the ton is sorted from every 6 tons mined. Therefore:

Cost of mining 6 tons @ $5.00 per ton	$30 00
Wagon or sleigh to railroad	2 00
Freight and treatment at smelter	10 00
Sorting 1 ton from 6	5 00
Total costs	$47 00

The value of one ton hand-picked ore being $50.00, there is only a profit of $3.00 on every 6 tons mined, against a profit of $5.41 as shown above on every ton mined when treated by oil concentration and cyaniding.

If we now consider the treatment of the large quantities of low grade ore lying on the dumps of many of the Slocan mines, and supposing the original ore averages $18.00 to the ton, and one ton is hand-picked from six, to the value of $50.00 per ton, there remains $58.00 in the other five tons, or $11.60 in one ton, which is equal to about 20.73 ounces silver. Treating this low grade ore by oil concentration and cyaniding, 42 per cent. and 37 per cent. respectively are saved.

Oil	42% of 20.73=8.70 ozs., worth $ .56 per oz.	$4 87
KCN	37% " 20.73=7.67 " " .56 " "	4 29

Smelters return 95 per cent. values. Total amount recovered from the low grade ore is $(\frac{95}{100} \times 4.87 = 4.63) + 4.29 = 8.92$.

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Cost of treatment per ton:

Mining.....	nil	(since it is already on the dumps.)
Removal to mill.....	50	
Oil concentration	1 00	
Cyaniding	1 27	
Smelters' charges, etc..	1 32	
Total cost	$4 09	

Amount saved, 8.92—4.09=4.83 per ton.

Looking, therefore, at the question of hand-picking, followed by treatment of the low grade ore as above, we have the following:

Value of 1 ton high grade ore.....	$50 00
Value of 5 ton low grade ore recovered; 8.92×5=.	44 60
Total value recovered from 6 tons mined.....	$94 60(1)
Costs of mining, sorting, smelting, etc., of 1 ton high grade	$47 00
Costs of treating 5 tons of low grade ore, 4.09×5....	20 45
Total costs 6 tons of ore.....	$67 45(2)
Profit on 6 tons of ore mined.....(1)—(2)=	27 15

Total value recovered on 1 ton of ore mined $\frac{27.15}{5} = 5\ 43(3)$

Comparing now this result with the former one we have:—

Profits on 1 ton of ore treated by oil and KCN.....	$5 41
Profits on 1 ton of ore sorted and then concentrated by oil, etc.	5 43
Difference in favor of last method.....	$0 02

That is to say, that the results are practically the same by the two methods. The figures on cyaniding are based on "Cyanide Practice at Ymir," as given by Mr. E. C. Holden in *Engineering and Mining Journal,* November, 1903, and from costs given in paper by Messrs. A. P. Griffiths and F. W. Oldfield, on "Cyaniding Some Silver Ores by Percolation."

In the calculations care has been taken to use only maximum costs, as in the case of consumption of cyanide. The maximum was found to be 4 lbs. to the ton, but in some of the experiments it ran as low as 2 lbs. per ton. There is no reason why the minimum might not be attained in practice, although a high consumption is to be expected with silver ores.

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The figures on oil concentration are those contained in a report by Mr. W. A. Freymuth, Consulting Engineer and Metallurgist for the Traversella Mines, Limited, on their mine in Italy. The costs of mining, smelting, etc., in the Slocan were supplied by a gentleman thoroughly conversant with mining and mining conditions in the district.

From the above calculations it may be seen that the Slocan "dry" ores are quite amenable to treatment by oil concentration and cyaniding, and give a fair margin of profit, but even better results may be obtained if the Hendryx process be substituted for ordinary cyaniding. They claim for this process an extraction of about 50 per cent. at the very low figure of from 25 cents to 50 cents per ton, and if these figures are reliable, the costs of treatment would be reduced by from 75 cents to $1.00 per ton, and the profits increased accordingly.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MICKLE—As I understand it, some of this ore was first of all treated by oil concentration and then cyanided, and in that way the total extraction was, approximately, 80 per cent. The only thing that seems strange—and Mr. Cavers said expressly that was not the case—is that you would have imagined that there would have been enough oil left in the tailings to have consumed the cyanide too much. I understand he said that it had not done so, and I would like to know if that was found from direct experiments or how?

PROF. KIRKPATRICK—That is one of the features disposed of by Mr. Cavers' results. He got a smaller cyanides consumption when he treated previously with oil, than when he treated first with cyanide and then followed with oil concentration.

DR. PORTER—I understand that Mr. Elmore claims that the oil will remove cyanide; but will not the residuum oil, in pulp which has been treated by the oil process interfere somewhat with the extraction? This pulp has been treated with the Elmore

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process before the cyanide. Were these tails from No. 19 the ordinary tails, and had they still the residuum oil which is always present in the Elmore tails?

MR. CAVERS—I did not test it. I got rid of most of the oil by washing.

DR. PORTER—The Elmore process never succeeded in getting tails containing less than a couple of gallons of oil per ton. Would not these tails possibly interfere with the extraction?

PROF. KIRKPATRICK—That oil, with the Elmore process, is in the concentrates practically.

DR. PORTER—A good deal of it is in the concentrates.

PROF. KIRKPATRICK—I understand the claim is made that the tailings are practically free from oil. The concentrates always contain from 10 to 15 gallons of oil per ton of concentrates, and working that down to original ore it is from one to two gallons per ton.

DR. PORTER—And the tailings are so free from oil that it could have no effect on the extraction? I have not experimented and I want information.

PROF. KIRKPATRICK—Apparently the results bear that out. Mr. Cavers practically corroborates that; he only got a small cyanide consumption.

DR. PORTER—It is scarcely possible to do Mr. Cavers' paper justice is discussing it without studying the paper. He has done an immense amount of work, and even though we listen very carefully to what he has said we cannot carry it in our minds. I, for one, wish to have an early opportunity to see the paper printed. It contains a great deal of valuable information, but I have only absorbed a small portion of it from hearing it read.

PROF. GWILLIM—I know a little about the ores in that district and I know what a hard problem they are. You have to crush very fine to liberate the sulphides, and if you try to save by water concentration you will lose nearly everything in the slime. It seems to me that the oil process is specially adapted to slimy material. I did not think it would be a success in the Rossland district on the coarse ores, but that it is specially valuable for saving values from the slimes in the Slocan. The ore has to be

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crushed very fine and you cannot concentrate by water efficiently. A good many experiments have been carried out in cyaniding and some in hyphosulphide by Mr. Cavers.

Up to the present time these dry ores have been shipped to smelters, after a laborious hand sorting. Various wet processes have been experimented with, but so far none installed. The Hendryx process of cyandiding and electrical deposition is said to prove highly efficient on the Arlington ore, and a mill of that description is contemplated.

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Journal of the Canadian Mining Institute, Vol. VII.

Student's paper, submitted for Prize Competition.

NOTES ON SOME DEPOSITS IN THE EASTERN ONTARIO GOLD BELT.

By C. W. Knight, B.Sc., Queen's University, Kingston, Ont.

Toronto Meeting, March, 1904.

Introduction.

The district in eastern Ontario to which auriferous deposits seem to be confined is some seventy miles in length and varies in width at different points along the belt; it is continuous through the counties of Peterborough, Hastings, Addington, Frontenac, and, to a small extent, Lanark. This paper will be confined more particularly to a description of the geology of the Belmont lodes in Peterborough county, township of Belmont; and also to a vein which was first worked during the summer of 1903, located on lot 24, concession 10, township of Barrie in Frontenac county and known as the Star of the East. The Boerth mine, township of Clarendon, in the same county, will also be referred to. These three localities are chosen because I spent some six weeks during the past summer at the mine first mentioned, and later about eight weeks at the Boerth. At the former mine I was working underground and had, therefore, a good opportunity for studying these interesting ore bodies.

One of the most important reports (with map) on the district is by Prof. Miller, Provincial Geologist for Ontario, published in the Report of the Ontario Bureau of Mines, for 1902. A very important geological map of the Madoc-Marmora mining district by Messrs. Eugene Coste and James White was published in 1886 by the Canadian Geological Survey, without text. Other literature will be found in the bibliography at the end of this paper.

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Geology of the District.

The geology of the gold belt has been summarized in the report(1) cited as follows:

"A series of diorites, crystalline limestones and various schistose rocks have been cut through by granite. This granite now forms most of the higher hills and ridges in the district, the diorites and accompanying metamorphic varieties occupying the valleys and lower lying areas. Overlying all the rocks mentioned are areas, here and there, of undisturbed Silurian limestone of the Black River and Birdseye formation, together with, occasionally small outliers of sandstone. . . . The granite was found in all cases where opportunities were offered for observing the relations of the rocks to be younger in age than either the diorite or crystalline limestone, the latter two rocks being cut by dykes of granite and its fine-grained variety, felsite. The term diorite will be used in the following pages in a wide sense to embrace not only dark colored igneous rocks but gneissoid and schistose varieties as well. The origin of some of the latter is not definitely known. The relationship existing between the diorite and crystalline limestone on the more western part of the belt was not so clear as in some of the more eastern exposures."

The diorites, thus defined, occupy a district the outline of which is approximately that of the letter S, bordered on the north and south by large masses of granite. The latter are cut by numerous coarse grained granite dykes of a pegmatitic nature, which represent the last stages of activity of the cooling and consolidating granite magma.

Figures 1, 2 and 3 are photographs taken for the purpose of illustrating the relationship between the granite, diorite and limestone series. No. 1 is a specimen from the vicinity of Meyer's Cave P.O., township of Barrie, Frontenac county; the white subangular fragments are crystalline limestone and they are enclosed in a basic rock belonging to the diorite series. The specimen photographed in Fig. 2 was found a little south of the Belmont gold mine and will be referred to again in a later part of this

(1) Report of the Ontario Bureau of Mines for 1902, p. 186.

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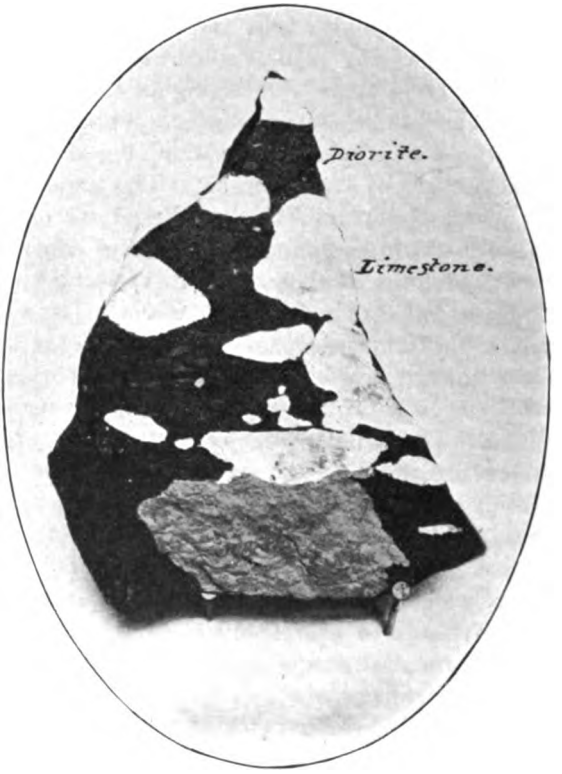

FIG. 1.—Fragments of crystalline limestone enclosed in diorite.
[Photo. by C. W. Knight.

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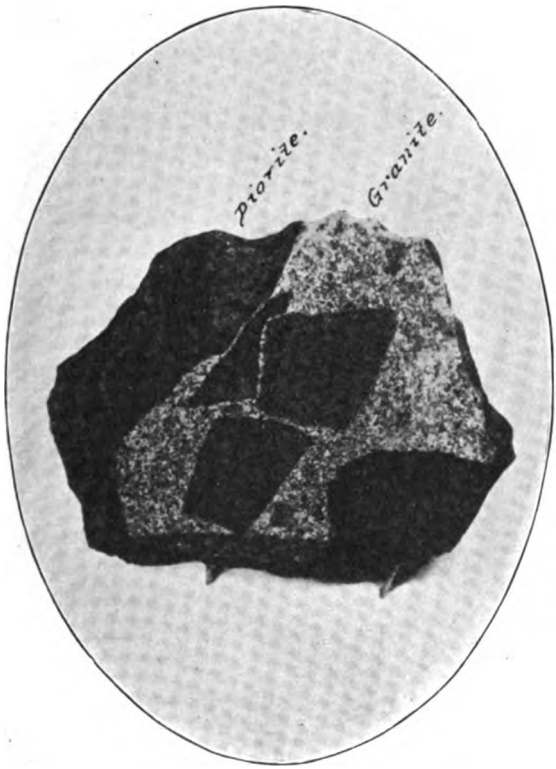

FIG. 2.—Fragments of diorite enclosed in granite.
[Photo. by C. W. Knight.

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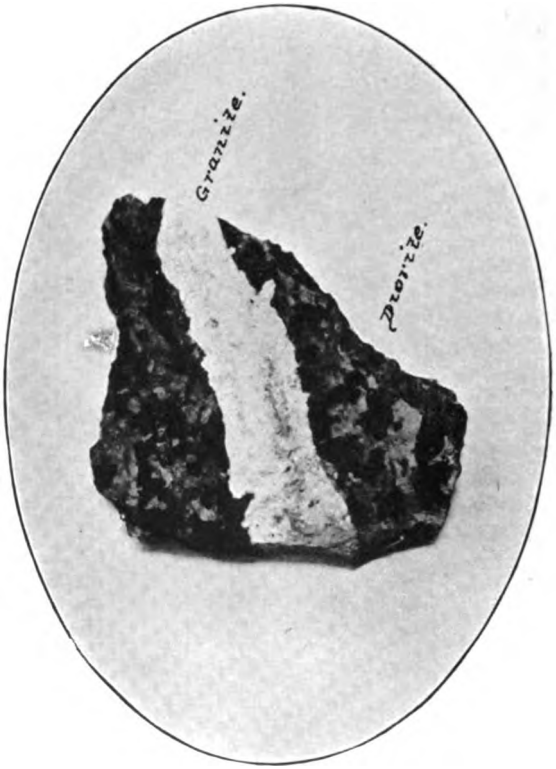

FIG 3.—Granite dyke cutting coarse grained diorite.
[Photo. by C. W. Knight.

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paper; the dark angular fragments are the fine grained variety of the gabbro found around the above mine and they are enclosed by granite. In Fig. 3 the light colored portion is an aplite dyke, which cuts through a very coarse grained variety of the gabbro near the same mine.

From these three photographs it can be seen that the relative ages of the rocks beginning with the oldest are:

(1) Limestone series
(2) Diorite series
(3) The granite

All these are of Archean age, the crystalline limestones, calc schists, etc., belonging to the Grenville series of the Laurentian. The stratified sedimentary limestones and sandstones which overlie these uncomformably are classified as Lower Palaeozoic.

The above sums up the results of those who have worked in this field. I have endeavored in this paper to throw some light upon five points:

1. The relation of the diorite to the limestone in the more western part of the belt, particularly at the Belmont mine.
2. The question of whether the diorites are of one or more ages.
3. The origin of the chlorite mica schist associated with the Belmont ore bodies.
4. The question of whether the granite has a genetic relation to the gold veins throughout the district.
5. The character of the Belmont ore bodies.

PART I.—The Belmont Gold Mine.

1. *The country rock in which the veins are found.*

The Belmont deposits were formed in gabbroidal rocks varying from very fine grained types to coarse grained varieties. From an exposure immediately southeast of shaft No. 3—cited by Prof. Miller in his report—two distinct rocks appear to be present. A sharp contact exists between the coarse grained gabbro and a fine grained trap-like variety. Examining the latter, say for one hundred feet southerly, it becomes gradually coarser in grain,

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showing that it has cooled against the coarser variety, which latter must have been in place before the other was intruded. Under the microscope this fine grained gabbro is seen to be made up mostly of green hornblende, pyroxene and plagioclase feldspar, together with some chlorite, pyrite and epidote. Titaniferous magnetite is very plentiful in small grains, and is always surrounded by a border of leucoxene. The latter has entirely replaced the magnetite in some cases. A short distance west of this point, fragments of the coarse grained type were observed enclosed in the finer grained variety, showing that the latter is younger than the former.

The feldspar of the gabbro is sometimes idiomorphic against hornblende and pyroxene, showing that the former mineral has crystallized out before the ferro-magnesian minerals. The pyroxene often forms plates of some extent enclosing lath-shaped crystals of plagioclase; this is known as the ophitic structure and is characteristic more particularly of diabase. A more detailed examination of the country rock will be found in a later part of this paper.

It may be stated here that in order to study the microscopic characters of the rocks in the vicinity of the Belmont mine, and also of the chlorite schist associated with the ore bodies of this mine, 39 thin sections were made and examined. In addition to these, a large number of hand specimens were collected during the past summer; some of these I have photographed for this paper.

2. Dykes in the vicinity of the mine.

A study of the dyke rocks near the Belmont mine shows that the relationship existing between the granites, diorites and crystalline limestones is that given in the above summary. Not far north of the village of Cordova, in which the mine is located, several fine grained dark colored dykes belonging to the diorite series cut the crystalline limestone and calc schist. One of these occurrences, at the forks of the Marmora and Van Sickle Settlement roads, is rather striking in appearance. This dyke is about three feet wide and near the contact has considerably altered the strike of the calc schist. A little further north a larger

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mass of the same rock outcrops, showing the same relationship to exist between it and the calc schist. In hand specimens the rock is seen to have a porphyritic structure, light greenish colored crystals about the size of peas forming the phenocrysts; these latter are now composed of chlorite which is probably secondary after plagioclase. Under the microscope the mass of the rock is seen to be composed of hornblende and plagioclase, the former predominating. The rock in the thin section examined was badly

FIG. 4.—Weathered calc schist near Belmont Gold Mine. Upper and lower surfaces are weathered portions.

Photo. by C. W. Knight.

decomposed, so that the plagioclase could not be determined. Chlorite is plentiful, this with a little calcite and quartz has resulted from the decomposition of the feldspar and hornblende. Pyrite is thickly disseminated throughout the dykes.

Several hundred yards north of the village schoolhouse the calc schist series is made up of two different bands which alternate regularly with each other. The bands vary in width from a fraction of an inch to as much as several inches. What appears

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to be the most silicious band is much harder and weathers less rapidly than the remaining parts of the rock. Fig. 4 is a photograph of this rock showing the unequal weathering; the upper and lower surfaces are the weathered portions. A thin section of this silicious material revealed the interesting fact that it is entirely free from calcite; the lime evidently re-acted with the other constituents to form certain lime silicates; amphibole—probably actinolite—has been largely developed, together with numerous crystals of plagioclase. These harder silicious bands have in numerous cases been brecciated and twisted into many curious shapes which have been isolated from each other by an inflowing

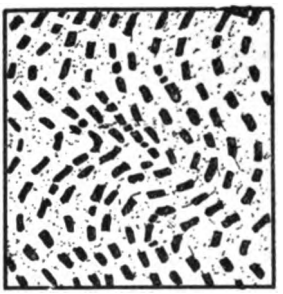

FIG. 5.—Brecciated calc schist in vicinity of diorite dykes. "Belmont Gold Mine."

of the limestone of the softer bands. Fig. 5 shows the manner in which they have been distorted.

It may be added that the origin of the banded structure has not yet been explained and an interesting paper might be written on this structure.

About half a mile south from Cordova village outcrops of a dark colored igneous rock are met with. In hand specimens it appears to be similar to that found on the Marmora road north of the mine and already described. It is cut by medium grained granite dykes, which sometimes contain fragments of the diorite; these inclusions are usually quite angular and pointed, but in some cases it is seen from the rounded corners that a certain amount of the diorite has been absorbed by the granite magma. Fig. 2 is a

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photograph showing irregular pieces of diorite enclosed in the granite. Such a fragmentary structure of the diorite, along the contact with granite dykes, was noted at several points, more especially south of shaft No. 3.

Not far north of Mr. Young's house, which is about a mile south from the Belmont mine, an interesting example of contact metamorphism was noted. A mass of igneous rock has cut through the crystalline limestone, causing a zone of garnets to form in the latter rock at and near the contact; most of the garnets are in crystals—rhombic dodecahedrons—varying in size from peas up to two inches; much, however, is massive. The intruded mass has the characteristics of a dyke, being more fine grained at the contact than in the centre. In hand specimens it is seen to contain some orthoclase, but the large amount of epidote seems to indicate that considerable plagioclase was originally present. A thin section showed the ground mass of the rock to be holocrystalline and made up principally of epidote, together with hornblende pyroxene and small amounts of feldspar. The structure is porphyritic, phenocrysts of plagioclase and orthoclase being set in a ground mass. Apatite is present sparingly. Wavy extinction is characteristic of the feldspar and hornblende, and fragments of the former mineral broken off from the crystals indicate that the rock has been subjected to pressure. Furthermore the rock has a marked schistose structure, the minerals tending to arrange themselves in parallel layers. Some of the garnets in the limestone have been flattened out. It is evident, therefore, that this dyke has been subjected to a certain amount of pressure since its intrusion into the limestone.

Perhaps one of the first things that would attract the attention of a geologist is the great number of granitic intrusions which ramify in all directions through the gabbro which forms the rock around the mine. They vary in size from mere threadlike stringers up to those a few inches in diameter. A microscopic examination of a very fine grained variety a little south of shaft No. 3 revealed a beautiful micro-pegmatitic intergrowth of quartz and feldspar, the latter consisting largely of orthoclase but with

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some acid plagioclase, together with a small amount of microperthite. Muscovite is present sparingly in small flakes.

It is to be noted that the granite dykes are most numerous near the veins, and further, that their occurrence in the gabbro is more frequent than in the limestone series. Professor Miller has observed that these acid intrusives are in no case found cutting through the veins, so that it is clear they were in place previous to the formation of the lodes. This relation was confirmed wherever I had an opportunity of examining the relation of the granite dykes to the Belmont deposits.

At the company's power plant near the foot of Deer lake, about two and a half miles northwest of the mine, the country rock is a greenstone schist. At one point in the rock-cut made for the waterpipe this schist is cut by a small trap dyke a few inches in diameter. This latter consists mostly of green hornblende with some secondary chlorite, but epidote, calcite, quartz and feldspar are present in less quantity and also magnetite and pyrite. The dyke has been considerably altered both by surface weathering and pressure. Chlorite is the most plentiful mineral in the greenstone schist, but calcite, feldspar and hornblende are all of common occurrence, together with a little quartz and magnetite. A thin section was examined of a rock which had been taken at the contact of the schist with the dyke. The contact is seen to be sharp and clear, and only a few isolated crystals of the intrusive rock had made their way a very small fraction of an inch into the schist.

The relation between the limestone series and the greenstone schist was not determined, but the latter is obviously older than the massive gabbro surrounding the Belmont lodes, because it is cut by fine grained dykes of gabbro. It is possible that the greenstone schist here described is a metamorphic variety of the diorite series; if this is the case it would seem that the diorites throughout the belt are of at least three distinct ages.

3. *A microscopic examination of the schists associated with the deposits.*

In order to study more carefully the character of the veins numerous specimens were selected from different shafts of the

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mine but more particularly from the 400 foot level of shaft No. 1. Referring to Fig. 6 it is seen that at the 300 foot level the vein divides into two parts so that at the lower of these two levels the two branches are about 30 feet apart. A cross-cut runs from one lode to the other at this point. Samples were taken every two feet beginning at C and ending at B, which is a little past the

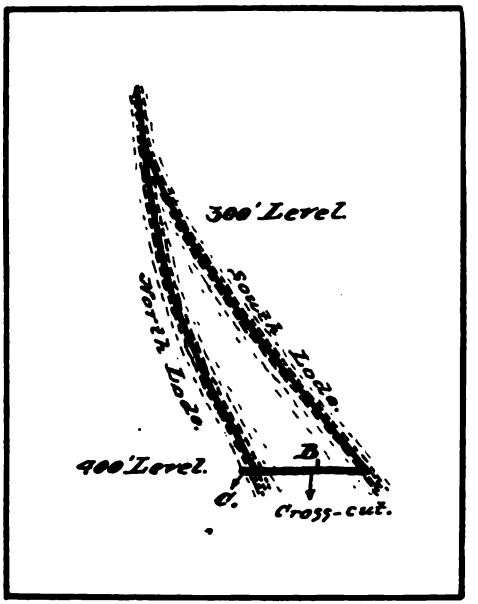

FIG. 6.—Vertical cross-section showing veins at 3rd and 4th levels, Shaft No. 1, looking East. "Belmont Gold Mine."

centre of the cross-cut. At C an excavation has been made into the foot-wall to accommodate a large pump. It was thus possible to obtain a fairly fresh specimen of the gabbro at this point. No fresh pieces of the country rock can, however, be found anywhere around the Belmont lodes, probably because of the action of heated waters and also of surface weathering.

Specimens were also taken every two feet on the south lode, (see diagram 6), but at a point about 50 feet east from the cross-

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cut connecting the two lodes. It was not possible, however, to get so far into the country rock as in the other vein.

A study of these two series of specimens by the unaided eye, but more especially of the first set, is sufficient to show the gradual transition from the country rock into a chlorite mica schist, and the microscopic examination which is given below confirms this statement. As no description of such a series of thin rock sections has been previously given, the results are stated in some detail. The thin sections are numbered beginning at the point C in Fig. 6.

It might be noted here that the chlorite schist forms a considerable part of the ore; stringers and veinlets of quartz, feldspar and calcite containing free gold ramify through the schist but in most cases are interstratified with it, together with pyrite carrying high values in gold.

Microscopic Description of 13 Slides Taken, Beginning at C and Ending at B, Fig. 6.

Slide No. 1—

The feldspar is a basic plagioclase cloudy and badly decomposed to epidote, chlorite and quartz, so that the twinning lamellae have nearly all disappeared; when these are present the highest extinction obtained by the statistical method for the determination of the feldspars was 20 degrees. This extinction angle is not far from that of the plagioclase feldspar labradorite. In a thin section, which I have not described in detail, a Carlsbad twin showing albite twinning lamellae gave the characteristic extinction angles for labradorite (Ab_1 An_1). The ferro-magnesian mineral, which in places is seen to have been originally diallage and augite, is not so badly decomposed, although frequently passing into chlorite and green fibrous hornblende. As accessory minerals, magnetite and pyrite are always present, the former being often surrounded with leucoxene as a secondary product from it; apatite in exceptionally large idiomorphic crystals is also present. Epidote is common as a secondary product from the

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decomposition of the feldspar. Introduced calcite is present sparingly and always associated with pyroxene; it replaces the latter mineral along the cleavage planes and cracks, and a very small amount of the introduced quartz seems also to have replaced the same mineral. The calcite has been introduced by mineral bearing solutions and is not a secondary product from the decomposition of the rock, and it is to be carefully noted that in nearly every case, both in this and the following thin sections, this mineral is most closely associated with the pyroxenes and hornblende and not with the original feldspar. An exception to this statement is found when the calcite replaces the *introduced* feldspar of the vein material as described later.

Slide No. 2.

The feldspar is very much more decomposed than in No. 1 and the albite twinning lamellae have almost entirely disappeared. Epidote, zoisite, chlorite and quartz have been abundantly formed as secondary products from the feldspar. The pyroxene has been replaced to a greater extent by introduced calcite, in some cases almost entirely only a small kernel of the pyroxene remaining. The calcite also occurs in small stringers and veinlets running through the rock. Chlorite is much more abundant and is beginning to arrange itself in parallel layers, which give the rock its schistose appearance in hand specimens; disseminated throughout the chlorite are, here and there, flakes of biotite which are altogether absent in the previous section; quartz though not common is more abundant and magnetite and pyrite are both present.

Slide No. 3.

The plagioclase has passed almost entirely into the secondary minerals mentioned, together with biotite; the wavy extinction and distorted and curved twinning lamellae of the feldspar give evidence of crushing in the rock. Chlorite together with a good deal of biotite now forms a large part of the specimen; quartz, and especially calcite have increased in quantity, and as usual, replace the pyroxene and secondary hornblende; calcite was also observed to be forming at the expense of some large apatite crystals. A mineral with high relief, parallel extinction and deep

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brown color (mentioned in the next slide) appears to be forming as a secondary product from magnetite.

Slide No. 4.

The feldspar is entirely lacking and the material has now assumed a typical schistose structure with parallel layers of chlorite, biotite, calcite and quartz. Magnetite and pyrite are both present. It is to be carefully noted here that while some of the pyrite was originally present in the gabbro and some of it has been since introduced, the magnetite, on the other hand, was all originally present in the gabbro, and has *not* been deposited by mineral-bearing solutions. The biotite is generally most intimately associated with chlorite and without the microscope its presence would not be suspected in many cases. The chlorite often appears to be isotropic, or else with very low interference colors. The mineral with high relief, referred to in the last section, has been developed also in this specimen; it appears to be rutile, and is quite plentiful in irregular masses, which, with a high power, are seen to be made up of a large number of long, narrow crystals, resembling somewhat a cigar in shape.

Slide No. 5.

This is well within the vein material; no original feldspar remains, but very fresh orthoclase and plagioclase have been introduced. Wavy extinction in the feldspar and a curving of the twinning lamellae indicate that the material has been subjected to pressure. The mass of this section consists of chlorite, quartz, plagioclase and calcite, the latter mineral replacing the feldspar along the cleavage planes and around the edges. Biotite is present sparingly. From the relation which the quartz bears to the calcite it is also evident that the latter mineral was deposited after the quartz, which probably was precipitated at the same time as the feldspar. Rutile again occurs, together with pyrite and magnetite.

Slide No. 6.

The section is also of vein material, containing a moderate amount of introduced plagioclase with the usual replacement along

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cracks and cleavage planes by calcite. The chlorite is arranged in roughly parallel layers, which give the material its schistose structure in hand specimens; biotite is intimately associated with the calcite.

In some cases all transitions can be seen between what is regarded as rutile and what is obviously magnetite, so that it would seem that the former mineral has been formed from the magnetite. Segregations of this titaniferous magnetite are sometimes seen in the gabbro surrounding the Belmont deposits, and a sample of such an occurrence analysed by Prof. Miller showed it to contain nearly 12 per cent. of titanium dioxide, so that rutile might form from such a magnetite. The iron oxide remaining would be dissolved away and probably combine with the other elements which have formed the numerous secondary minerals mentioned.

Slide No. 7.

Calcite, quartz, chlorite (without biotite) and introduced plagioclase form the greater part of the specimen; the feldspar shows wavy extinction in some cases. Portions of the original plagioclase are suggested by the fine granular mass of epidote, zoisite, chlorite and quartz. The schistose structure is not so marked as in sections 4, 5 and 6.

Slide No. 8.

The plagioclase can be made out in a few cases showing the albite twinning lamellae; it has, however, mostly passed into epidote, zoisite, chlorite and quartz, but the effect of the mineral bearing solutions on the rock is beginning to be less marked. The ferro-magnesian mineral present is mostly hornblende, showing many twins having the ortho-pinacoid as the composition face; it is replaced to a small extent by calcite. Wavy extinction is common with the hornblende. The specimen is well outside the vein material, and the structure approaches that of a gabbro, although in hand specimens it has rather a gneissic appearance.

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Slide No. 9.

The plagioclase is represented largely by epidote, zoisite and a little quartz. The mineral which is present in largest quantities is a ferro-magnesian mineral which was probably originally augite (or diallage), but it has been largely altered to hornblende and to a less extent chlorite. Calcite is present in very small quantities associated with the hornblende and pyroxene. Pyrite and magnetite (with the usual band of leucoxene surrounding it) are always present. The structure is the same as Slide No. 8.

Slide No. 10.

This is very similar to the previous specimen, but augite and hornblende are not present in so great quantities. Large pieces of epidote and zoisite are of frequent occurrence.

Slide No. 11.

Sections Nos. 8, 9 and 10 are the least altered of any specimens that were obtained in the cross-cut between the two veins (See Fig. 6). These three were taken about the central part of the cross-cut. The minerals present in this thin section are about the same as in the last three, but chlorite, calcite, quartz and especially epidote and zoisite have increased in quantity. A little hematite was noted in this section. In some parts the structure is decidedly schistose.

Slide No. 12.

The most striking point about this slide is the large amount of secondary epidote and zoisite present, both of which have been formed at the expense of the plagioclase and probably the pyroxene. The twinning lamellae of the plagioclase can be made out in some few cases, but it has passed mostly into chlorite, quartz, epidote, zoisite and biotite. The pyroxene and hornblende have passed into chlorite or have been replaced by calcite; quartz, magnetite, pyrite, and a little hematite are all present.

The chlorite has arranged itself partly in parallel layers which give the specimen its schist-like appearance. Some biotite is intimately associated with the chlorite.

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Slide No. 13.

The gabbro has now passed into a typical schist; the large amount of chlorite which is present is arranged in distinct, parallel layers showing a fine mosaic of quartz and plagioclase feldspar between them. Some of the original plagioclase is still present, and is often surrounded by fragments of this mineral which have apparently been broken off from the large crystals. The mineral described in section 6 as rutile is also present, together with magnetite and pyrite. Calcite is present in small quantities.

The point from which the above specimen was taken is not very far removed from the vein material of the south lode. It was the last sample taken from the cross-cut and examined.

Nine specimens were taken every two feet from the south lode (see Fig. 6); from five of these, thin sections were made and examined. As already stated, it was not possible to get so far into the country rock as in the north lode, but some of the points brought out in the description given above of sections 1 to 13 are further confirmed in this series. A detailed description of them will therefore not be given.

The results of the above microscopic examination may be summed up as follows:

1. There is generally a gradual change from the country rock into the chlorite schist.

2. The pyroxene and hornblende have been partly replaced by vein (that is, introduced) calcite, and to a less extent by vein quartz.

3. By far the greater part of the calcite and quartz has been introduced, although some is probably secondary from the decomposition of the ferro-magnesian minerals and feldspars.

4. Although the original feldspar of the gabbro has in nearly every case entirely disappeared in the typical chlorite schist, nevertheless it is not replaced by calcite to anything like the extent that the pyroxene and hornblende have been.

5. There is evidence in the schist of crushing and shearing forces, which were responsible, to some extent, for the development of the schistose structure; but the intruded vein material

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and the action of the mineral bearing solutions on the gabbro are probably largely responsible for the production of the schistose structure.

6. A larger amount of introduced plagioclase is present in the vein material than an examination of hand specimens would indicate.

7. The tendency of the original plagioclase to pass into epidote, chlorite, etc., rather than to be replaced by introduced calcite is typical of the alteration of the gabbro into the chlorite schist.

8. The amount of introduced calcite and quartz becomes less and less as the distance from the vein increases.

9. Exceptionally large apatite crystals are present in the gabbro.

10. Chlorite is much more common in the schist than biotite, which is often entirely lacking, but where it is present it is very intimately associated with the chlorite. The schist may, therefore, usually be called chlorite schist, but where biotite is present it may be spoken of as a chlorite-mica schist.

11. An interesting point about the action of the vein (i.e., introduced) calcite is that while it commonly replaces the introduced orthoclase and plagioclase of the vein material, it rarely acts thus with the original plagioclase of the gabbro.

12. The calcite has been deposited after the introduction of the feldspar into the vein material.

13. The plagioclase of the gabbro is labradorite (Ab_1 An_1) and the original pyroxene was probably mostly diallage and augite. In the specimens examined, however, the ferro-magnesian mineral had passed mostly into green hornblende and chlorite.

14. The Belmont ore bodies may be classed as replacement deposits along fissures.

4. *The origin of the Chlorite Mica Schists associated with the deposits, and the form of the ore bodies.*

As already stated, the veins are contained in, and interstratified with, a chlorite and chlorite-mica schist, which is persistent throughout the entire course of the lodes, and sometimes reaches a width of 50 ft. The genesis of this schist is interesting.

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There are a number of points which show that the vein material and gabbro near it have been subjected to pressure and to shearing forces. In support of this statement the following points may be enumerated:

1. Wavy extinction in the feldspar, pyroxene and hornblende is a common phenomenon seen in thin sections from the schist and adjacent country rock.

2. The original plagioclase (and also the introduced feldspar) present in the chlorite schist frequently has its albite twinning lamellae curved and bent.

3. The plagioclase is sometimes surrounded by small angular fragments which have been broken away from it.

4. Slickensides are very numerous throughout the ore bodies.

It would seem, then, that pressure and shearing have formed the schistose structure in the vein material. The capability of these forces to produce this structure has long been known. There are, however, several points which show that pressure and shearing are not altogether responsible for the formation of the chlorite schists. For example, there are certain isolated chimney-like deposits in the gabbro enveloped by a collar of schist possessing the same structure, which could obviously not have been formed by shearing. Furthermore, there is generally a gradual transition from country rock to schist and no sharply defined contact, as is commonly the case in sheer zones (quetschzonen).

The action of highly heated water (containing in solution the elements which went to form quartz, calcite, orthoclase, plagioclase, pyrite, etc.), on the gabbro of the country rock probably had much to do with the production of the chlorite schists. A detailed study of the Belmont ore bodies has led me to support Prof. Miller's suggestion that the schistose structure was caused by the action of mineral-bearing solutions, but, for reasons given above, I think that shearing along the lines of the fissures must also be considered as an important factor. It is probable, then, that the chlorite schist has been formed by the *combined* action of shearing and mineralizing solutions, more especially the latter.

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Laboratory experiments by Daubrée have an interesting bearing on this subject, and the following paragraph is quoted from Geikie's Text Book of Geology.(2)

"Besides showing the solvent power of superheated water and vapour upon glass in illustration of what happens within the crust of the earth, Daubree's experiments possess a high interest and suggestiveness in regard to the internal re-arrangements and new structures which water may superinduce upon rocks. Hermetically sealed glass tubes containing scarcely one-third of their weight in water, and exposed for several days to a temperature below an incipient red heat, showed not only a thorough transformation of structure into a white, porous, kaolin-like substance, encrusted with innumerable bipyramidal crystals of quartz, like those of the drusy cavities of rocks, but had acquired a very distinct fibrous and even an *eminently schistose structure.* The glass was found to be split readily into concentric laminae arranged in a general way parallel to the original surfaces of the tube, and so thin that ten of them could be counted in a breadth of a single millimetre. Even where the glass, though attacked, retained its vitreous character, these fine zones appeared like the lines of an agate. The whole structure recalled that of some *schistose* and crystalline rocks."

The form of the ore bodies is lenticular and the stopes are placed in the centre of the lenses. The chlorite schist is always persistent throughout the veins, even where they become almost pinched out. Fig. 7 is a photograph of the typical schist associated with the veins.

5. *Origin of the mineral-bearing solutions.*

The form of the Belmont lodes, Fig. 8, shows that the gabbro has been divided into immense blocks by fissures along which the ore bearing solutions have precipitated certain minerals accompanied by replacement of the country rock, as has been proved

(2) Geikie's Text Book of Geology, Vol. I., p. 414, Ed. 1903.

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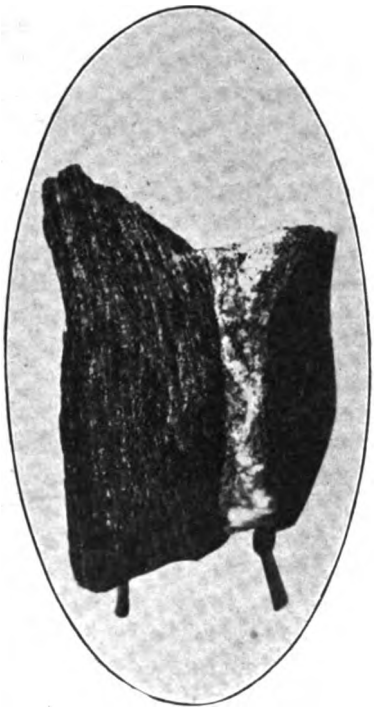

FIG. 7.—Typical chlorite schist. Belmont Gold Mine.
[Photo. by C. W. Knight

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by the microscopic examination in Section 3 above. The replacement has been accompanied by the production of a schistose structure in the country rock, in such a way that a gradual transition from the gabbro to a chlorite and chlorite mica schist is

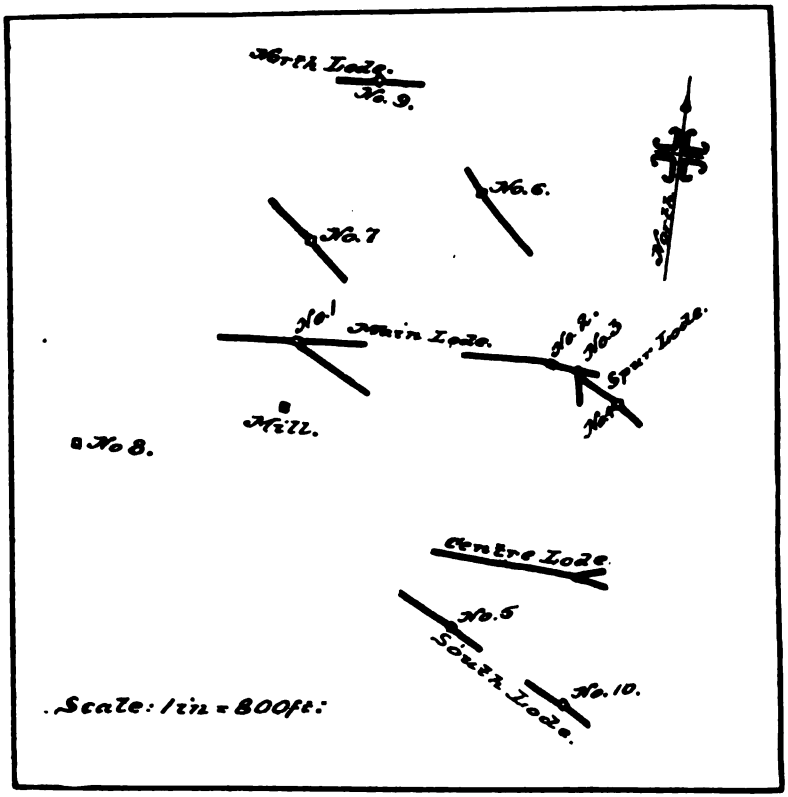

FIG. 8.– Surface plan of Belmont Mine, showing position of lodes and shafts. Adapted from diagram in Prof. Miller's report, Ont. Bur. of Mines, 1902.

typical of the entire deposits. In some places, however, this structure passes rather abruptly into the country rock. It may be noted here also, that the occasional presence of about two feet of quartz in the centre of the vein, showing a sharp contact with the chlorite schist, is suggestive of an open fissure in places.

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Whatever be the source of the gold-bearing solutions which formed the Belmont ore bodies and the other veins on the belt, it is a most noticeable fact that the lodes throughout the Eastern Ontario Gold Belt are closely associated with the granite eruptives. Recent papers by Kemp, Lindgren, Vogt and Spurr on the subject of ore deposits have brought into prominence the connection between ore deposits and igneous rocks. It has been pointed out that nineteen out of twenty important ore bodies have a genetic connection with associated igneous rocks. "Especially well marked is the connection of *ore-regions* or *zones* with areas or belts of igneous activity." (3) The Eastern Ontario Gold Belt may be considered as such a zone, and I shall try to show the close connection which the granites (lying to the north and south of the belt) bear to the ore bodies. This section, however, is confined more particularly to the origin of the mineralizing solutions which have formed the Belmont deposits.

A macroscopic and more especially a microscopic examination reveals large quantities of feldspar in the vein material. This mineral is fresh and clear, and in strong contact with the plagioclase of the gabbro, which is badly decomposed. The gangue feldspar has been replaced to a small extent by vein calcite, which ramifies through the cracks and cleavage planes and replaces the edges of this mineral. The calcite, therefore, has evidently been introduced *after* the deposition of the feldspar.

The presence of introduced feldspar and quartz in the vein material suggests a connection between the ore bodies and pegmatites. These latter are now considered to be formed not by dry igneous fusion, but by aqueo-igneous agencies accompanied by pneumatolytic action. That is to say, the magma (which on consolidation has formed a pegmatite) contains a large quantity of water at very high temperature, and also such mineralizers as fluorine, boron, etc. Ordinary quartz veins, on the other hand, have been formed purely under aqueous conditions. There are all gradations between these two stages. Now, on account of

(3) "A consideration of igneous rocks and their segregation or differentiation as related to the occurrence of ores." Paper by J. E. Spurr, p. 3. Trans. Am. Inst. Min., Eng., vol. XXXI.

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the presence of granitic material in the Belmont ore bodies, it is probable that they have been formed under conditions which were intermediate between those conditions necessary to form a pegmatite and those which were necessary to form an ordinary quartz vein. The presence in the vein material of a large amount of calcite which is not found in pegmatites shows that the lodes have partly the nature of ordinary quartz veins. This calcite may have been leached out of the limestone which occurs in such large masses near the mine.

Pegmatites also pass by insensible degrees into dykes, so that three main divisions stand out clearly defined: (1) Dykes, (2) Pegmatites, (3) Ordinary quartz veins. All transitions are believed by geologists to exist between these three divisions. Since it has been proved that the granite is the youngest igneous rock in the district, and in no case is found cutting the ore bodies, it would seem that the Belmont deposits owe their origin to these eruptive masses.

Certain gold-bearing quartz veins in the Yukon district appear to have originated like these deposits, and a paragraph is here quoted from a paper by J. E. Spurr, (2) which has some bearing on this subject:

"It has been concluded that certain quartz veins in the Yukon district (part at least of which are auriferous) have originated by a process of magmatic segregation, which has separated them from other materials while in a state of aqueo-igneous fusion (the condition of molten rock in general), and that they represent the siliceous extreme of that process. From this standpoint they are a variety of the igneous rocks. But it has been shown that as magmas becomes more siliceous, they also contain more water; so, when the stage of quartz veins is reached, the magma is believed to be so attenuated, that it may be best described as water highly heated and heavily charged with mineral matter in solution. There would thus be no great difference (save in their associa-

(1) "A consideration of igneous rocks and their segregation or differentiation as related to the occurrence of ores."—Paper by J. E. Spurr, 1902, p. 24., Trans. Am. Inst. Min., Eng., Vol. XXXI.

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tions, and very likely in the selection of the mineral matters which they contain) between those solutions and others where the water may have had, say, an atmospheric origin; and a quartz vein originating by magmatic segregation might often not be distinguishable from one formed in the many other ways which are possible."

The same writer asserts also that "in one and the same dyke the change from a coarse alaskite (quartz and alkali-feldspar) to a typical quartz vein may be seen in all its stages."

PART II.—The Star of the East Gold Mine.

1. *Introduction.*

The Star of the East Gold Mine is particularly referred to in this paper because of the peculiar combination of minerals which are found in the veins, and because no similar occurrence has been before noted on the Eastern Ontario Belt.

Two veins have been located on the property and it is claimed by the owners that they can be traced for half a mile on the surface. They are about twenty yards apart and run parallel in a more or less easterly and westerly direction. At the time of my visit in October, 1903, three openings had been made on the south vein, the deepest of which was not over 25 feet, the other two each being much less. The width of the vein material is from 8 to 10 feet. On the north lode a pit 10 feet deep has been sunk showing about 4 feet of ore.

The rock in which the deposits have been formed is a white, fine grained crystalline limestone belonging to the Grenville series of the Laurentian. Prof. Miller's map of the district shows that the nearest outcrop of granite is about 1 mile to the north where large masses of this rock occur. The time which I spent at the mine was only sufficient to examine the openings and part of the country between the mine and Marble Lake (see map annexed), which lies about the length of a lot to the southwest. It is possible that dykes of granite may exist nearer than is yet known.

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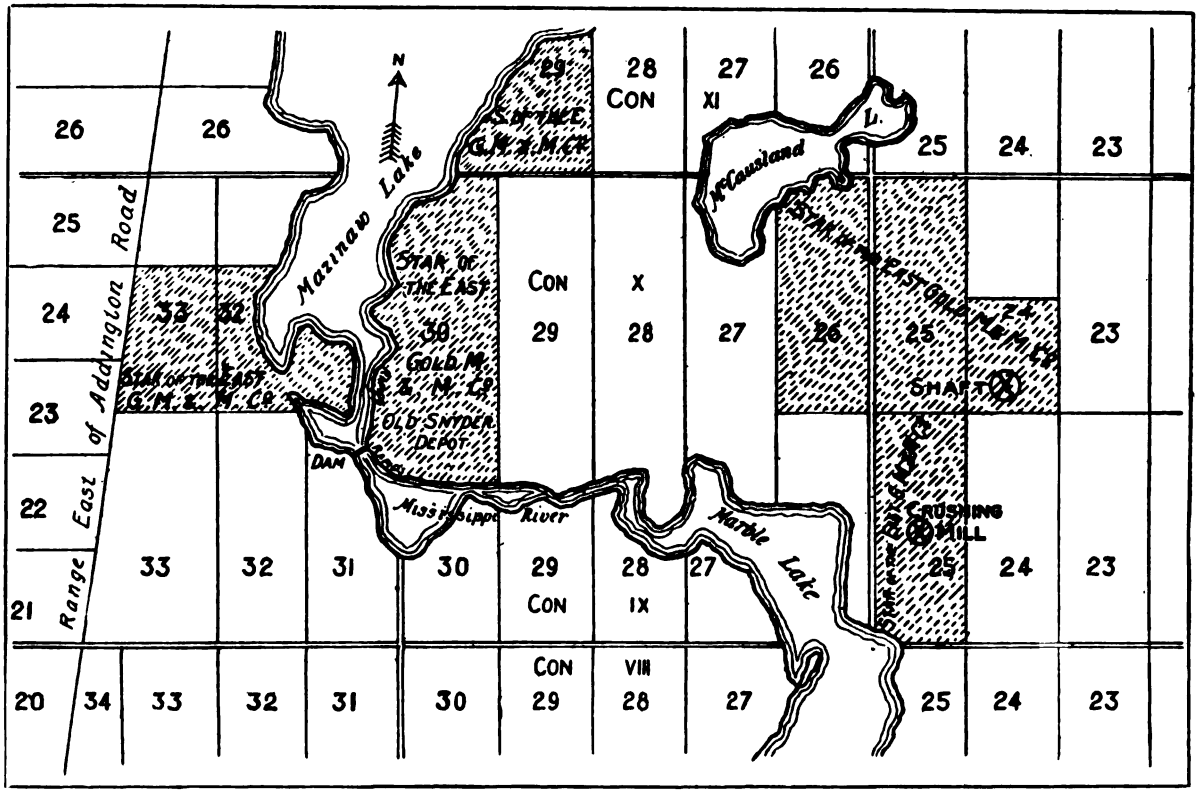

MAP: Part of Township of Barrie, County of Frontenac, Ont., Canada

Showing location of properties of the Star of the East Gold Mining and Milling Co., Limited
Lot No. 31 also belonging to the Company

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2. Form of the ore bodies.

As already stated, the veins—which have a vertical dip—are found in crystalline limestone. The walls are commercial, i.e., there is no sharply defined line between what is vein material and what is country rock. The lenticular masses shown in Fig. 9 are quartz. They vary in length from 6 to 24 inches and are as thick as 4 inches in some specimens. Sometimes they are surrounded by a band of actinolite, which has been largely altered to chlorite.

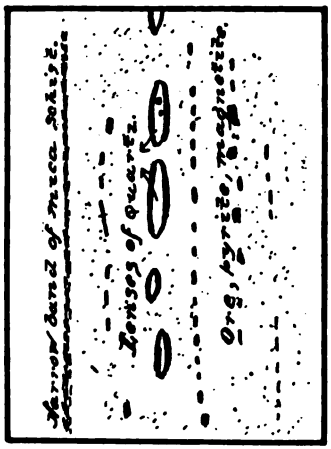

FIG. 9.—"Star of East Gold Mine" Diagrammatic vertical section showing arrangement of small lenticular pieces of quartz. The ore is disseminated in vertical stringers and masses on each side.

Fig. 10 is a photograph of one of these masses showing its lenticular outline. A cross section of the vein as shown in the deepest shaft on the property shows the quartz lenses to occur one above the other and in the centre of the lode. They have been quite isolated from each other being entirely surrounded by the limestone of the country rock and also by some secondary calcite. It would seem that these lenticular masses of quartz now represent the position of a vertical fissure, which was at one time present in the limestone. Fig. 11 is a photograph of one of the pits showing the vertical dip of the vein. A narrow band of mica schist,

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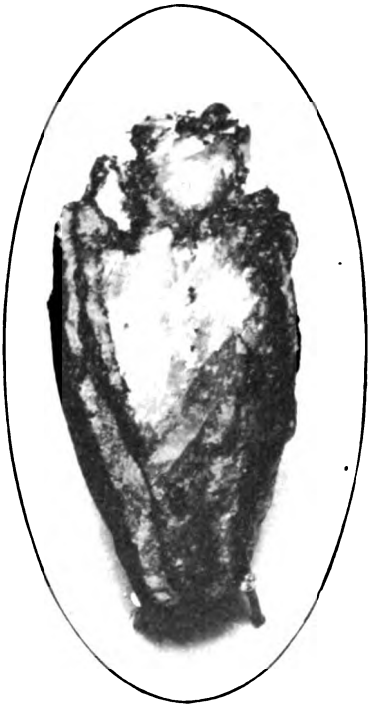

FIG. 10.—Quartz from "Star of the East Gold Mine," showing lenticular outline.
[Photo. by C. W. Knight.

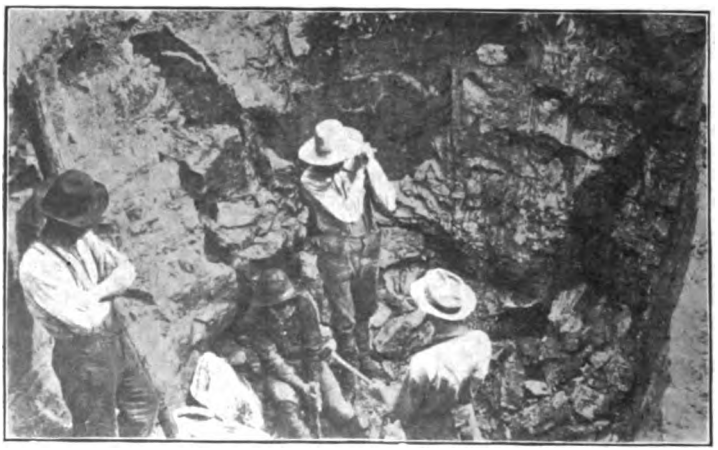

FIG. 11.—Pit No. 1. "Star of the East Gold Mine," Frontenac Co.

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which was found near the south edge of the vein, seems to indicate the position of a shear zone. Its contact with the limestone is sharply defined. (See Fig. 9).

3. *Minerals found in the vein.*

The minerals found at the Star of the East Mine are: pyrite, magnetite, actinolite, mica (not common), quartz, calcite, a small amount of galena, and chlorite, which latter is secondary and probably was formed at the expense of the actinolite. Magnetite sometimes occurs in beautiful little octahedra. The peculiar association of a sulphide with an oxide is to be particularly noticed because from the physical relationship which they bear to each other both were evidently formed at the same period. The presence of an amphibole—actinolite—intimately associated with the other minerals is also to be noted. It may be added that the association of a sulphide with an oxide is not an uncommon occurrence in nature, but such a combination in an ordinary gold bearing vein is unusual.

4. *Origin of the mineral bearing solutions.*

The minerals mentioned in the above section are those which are characteristic of contact deposits. A contact deposit is one found at or near the contact of an igneous and sedimentary rock. It is now generally believed that such ore bodies have been formed by the action of gases and vapours given off by the igneous rock with which they are in contact. In other words they are the result of pneumatolytic action. From the association of minerals found at the Star of the East mine it would seem that these ore bodies are the result of pneumatolytic action, and that the aqueous gases (laden with metallic compounds) have been derived from the cooling granite magma which surrounded the eastern Ontario gold belt. The lodes cannot be classed as contact deposits because they resemble ordinary quartz veins in that they seem to be connected with fissures.

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5. *A summary of the points which go to show the genetic connection between the granite and the ore bodies throughout the eastern Ontario gold belt.*

(*a*) A high percentage of mispickel in a large number of the ore bodies throughout the belt seems to show that they have been formed under similar conditions.

(*b*) The presence of a large amount of feldspar and quartz in the vein material of the Belmont lodes is suggestive of pegmatites and consequently of a genetic connection between the granite and these ore bodies.

(*c*) The granite is the youngest igneous rock in the district and in every case was formed before the veins, which, however, are always in close proximity to it, throughout the belt.

(*d*) From the association of minerals found at the Star of the East it would seem that these lodes owe their origin to pneumatolytic action which accompanied the intrusion of the granite magma throughout the belt.

(*e*) To further emphasize the genetic connection between the granite and the gold veins of the eastern Ontario gold belt, the Boerth mine in Hastings county may be referred to here. The veins at this property contain a very large percentage of mispickel and tourmaline, which latter is not confined altogether to the lodes, but is found in other places near the mine in stringers of quartz cutting across the strike of the country rock. It occurs also in *small cracks, which run off at right angles from* the veins, replacing the country rock (which consists of various schists) and forming in some small areas a tourmaline schist. This is very characteristic of pneumatolytic action. Tourmaline is formed in nature in two ways: (1) By metamorphism, regional or local; (2) by pneumatolytic action. Black tourmaline (which occurs at the Boerth) is particularly common when formed in the second way mentioned. It is highly probable, therefore, that these veins have been produced by pneumatolytic action which accompanied the uprise of the granite magma in the district.

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Concluding Remarks and Acknowledgments.

The subject under discussion has been treated altogether from a geological point of view, so that a few remarks of a general nature will not be out of place here.

The gold throughout the belt is found in two states: (1) free, (2) intimately associated with a sulphide or an arsenide. In the latter case the values are obtained by separating the concentrates from the gangue on Wilfley tables and treating them by some wet method usually cyaniding. It is only lately that this process has come into use in the largest plants on the belt, such as the Belmont and Deloro; and in fact it is only during the past five years that the ores have been successfully treated. This is on account of the refractory character of the ore.

The Belmont mine is equipped with 30 stamps of 850 pounds each, 6 Wilfley tables and a cyaniding plant for treating the concentrates. The ore is hand culled, so that the average values treated in the mill will run between $5.00 and $6.00 per ton. The company has installed a magnificent compressor, Fig. 12, at the

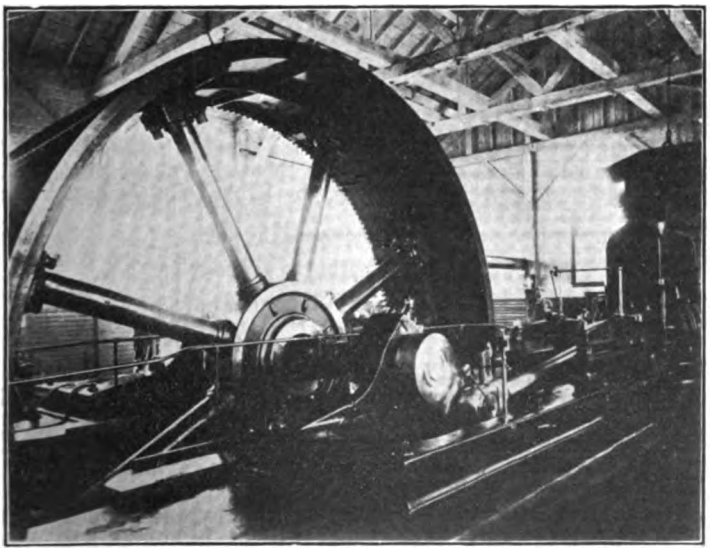

Fig. 12.—Compressor, "Belmont Gold Mine," Peterboro' Co.

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foot of Deer Lake, about two and a half miles from the mill. Eight hundred horse power can be generated by this plant, which supplies air for the pumps, drills, hoists and electric plant. The shafts and drifts are, as far as possible, installed with incandescent lights. Detailed accounts of the plant and development work will be found in the various reports of the Ontario Bureau of Mines.

Acknowledgments.—I wish to thank Prof. Miller for his interest in this paper, and to say that he suggested the eastern Ontario gold belt as a field in which to work along geological lines. I also wish to thank the professor in the department of geology at Queen's University and the School of Mining.

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NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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DISCUSSION.

PROF. MILLER—There are some gentlemen present who are well acquainted with the Eastern Ontario gold belt, and some who have worked over it quite carefully.

MR. M. B. BAKER—On Lake Abittibi we find diorites resembling the diorites in Eastern Ontario. On the shores of the lake above water mark there is a rock with no traces whatever of a schistose character, whereas down by the water's edge and especially along cracks, where it is exposed both to the air and to the water, it has become a chlorite schist which you can easily shell off with your fingers, while above water mark you can hardly break it with a hammer. Independent of shattering action at all, solutions will produce schists not unlike those in Eastern Ontario. Another point which Mr. Knight brought out clearly was that these veins are not the ordinary veins that we consider as true fissures, but that they seem to follow lines of weakness induced by the presence of solutions and possibly shattering and shearing; the solution percolating would give the schistose condition. As regards the age of these rocks, I do not think there is a doubt in the mind of anyone who has been over the district. I think Mr. Knight's theory as to the age of the formations is quite correct. The formation of veins being the cause of the schistose appearance, that is also borne out by my experience in that district.

MR. MILLS—I have listened to this paper with a great deal of pleasure and I wish to say that the results coincide fully with my experience. I shall wait with anxiety to see the paper in print so that I may understand it better.

PROF. MICKLE—I hope to hear a little dispute from the geologists on this paper. We all know that geology is not an exact science and that one can hold almost any view, without it being possible to prove whether he is right or wrong. Since Mr. Knight struck that aplite dyke early in the paper I got into trouble and I want to see others follow suit.

MR. FRALECK—Mr. Knight has chosen two of the most interesting deposits; the Belmont on the extreme west of the Hastings gold belt and the Star of the East almost on the east. The writer

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might have emphasized the great difference in the physical characteristics of the two ore bodies. In the case of the Belmont, large well defined lodes of low grade ore; in that of the Star of the East and Boerth, narrow tricky lenses of very high grade ore.

Many of the failures in that district in my opinion are largely due to lack of appreciation of this distinction. I am rather doubtful that granite bosses have had the same influence on the eastern deposits that they had at Belmont and Deloro, but am not familiar enough with the conditions at the Star of the East to thoroughly discuss the question now.

MR. MILLS—Late last fall I made a visit to the Boerth mine and I was informed that gold amounting to $20 per ton was left in the tailings. That is rather interesting if a positive fact, and I should like to learn something about it from an independent source.

MR. FRALECK—That hardly seems conceivable. I should imagine that 75 cents would be more like it.

MR. BAKER—I conversed with a man who spent one summer there, and he showed me a great many samples which were full of free gold. He said that the process was very crude, and that they had undoubtedly lost a large part of their values, but I do not think it was anything like that mentioned by Mr. Mills. As to the difference in the ores between the east and west, there is another point which bears out the idea that there must be a different explanation for these deposits. There is probably not a common cause for both formations. The specimens I saw were quartz, mispickel and free gold.

PROF. MILLER—I regret that our President, Mr. Coste, is not here to listen to Mr. Knight's paper. As some of you know, about fifteen years ago Mr. Coste worked over a part of that district very carefully, and he prepared one of the most perfect and detailed geological maps we have of any part of Canada. I am sure that this paper would have been very interesting to him. I also regret that Mr. D. G. Kerr, late manager of the Belmont mine, is not able to be with us, because he would be glad to hear of the results of Mr. Knight's work.

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Journal of the Canadian Mining Institute, Vol. VII.

ON A MINERAL CONTAINING "RADIUM," IN THE PROVINCE OF QUEBEC.

By J. Obalski, M.E., Inspector of Mines, Quebec.

Toronto Meeting, March, 1904.

Since the new element, "radium," has been discovered, much attention has been called to the minerals containing it; so far it appears that the Uranium ores are the only ones in which it has been found.

In our Laurentian formations, uraninite, composed of oxide of uranium and other rare metals, has been met with in some pematite dikes, which have been operated as producers of white mica (muscovite), and we have the records of the Villeneuve mine, in the Ottawa county, with monasite and uraninite, and of the Maisonneuve mine, in the county of Berthier, with samarskite; we have also several other white mica mines and prospects in the Saguenay district, but so far uranium ores from these have not been noted.

About ten years ago, I found in a mine of the Saguenay district, then operated by the "Canadian Mica Co.," a remarkable specimen which I identified as "cleveite," and which is shown in the accompanying photograph(1).

This specimen has a specific gravity of 8.43, and weighs 375 grammes, or about 13 ounces. It is well crystallized in a dodecaedron form, deriving then from the isometric system. A complete analysis has not yet been made, but it contains 70.71 per cent. of uranium oxide.

Radium having been discovered and found to exist mostly in connection with uranium ore, I experimented with the above

(1) Photograph No. 1 shows the crystal of Cleveite (natural size) used for obtaining the radiographs Nos. 2 to 8, shown in this paper.

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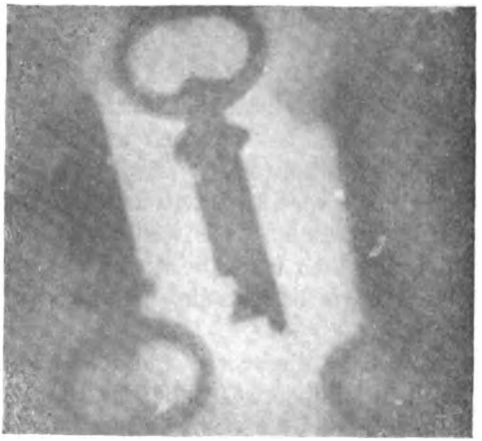
No. 1.



No. 2.

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mentioned crystal, and found it affected strongly the photographic plates, as shown by the accompanying radiographies(2).

The specimen has also a well marked action on the electroscope. I came then to the conclusion that it contained radium, and to have my opinion confirmed, I showed the specimen to Professor Rutherford, of McGill University, who, after testing it, stated that its radio-activity was equal to four or five times the activity the crystal would have if it was entirely composed of uranium, and that it contained one-tenth of a milligram of radium, making it comparable with the best pitchblend so far operated for the production of radium. This crystal may be an accidental one, although I have found other small pieces of the same mineral in this vein, but I have also found in the same a carbonaceous material burning quite easily, and leaving ashes containing oxide of uranium. The specimens of the above coal have been tested by Mr. Milton L. Hersey, of Montreal, with the following results:

This "coal" has a fibrous, irregular structure, and contains a small amount of mica; it proved to be of a similar nature to a non-coking bituminous coal, yielding considerable gas, which burned with a bright yellow flame.

Volatile matter (including volatile combustible matter and a small quantity of moisture)	40,185
Fixed Carbon	52,590
Ash	7,225
	100,000

The ash itself was analyzed and found to contain 2.56 per cent. of uranium, based on the coal, which is equal to 35.43 per cent. of uranium in the ash itself.

It is important to note that the color of the ash was olive green, being due to the presence of oxide of uranium.

In another test, the coal was not burnt, but was merely finely pulverized, and the powdered coal treated with boiling nitric acid,

(2) Nos. 2, 3 and 4 were taken through wood with a 9 hours' exposure. No. 4 is a radiograph of silver coins; No. 5 is also a radiograph of a silver coin, but through galvanized iron and after a 26 hours' exposure; No. 6 is an impression of the crystal of Cleveite itself after a 9 hours' exposure, and Nos. 7 and 8 are impressions of other specimens of the same material after the same exposure.

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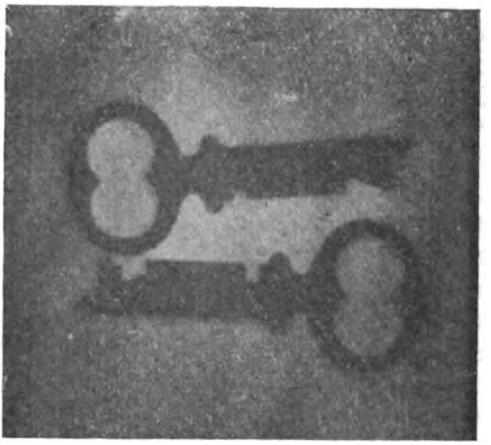

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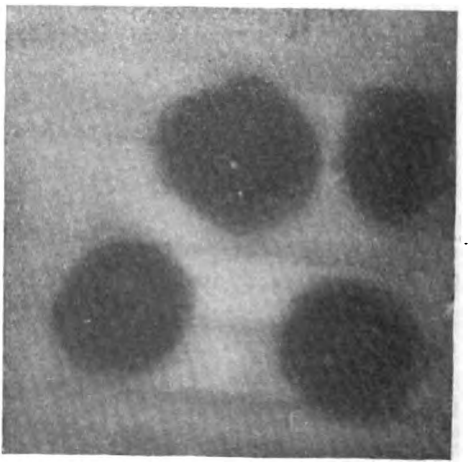

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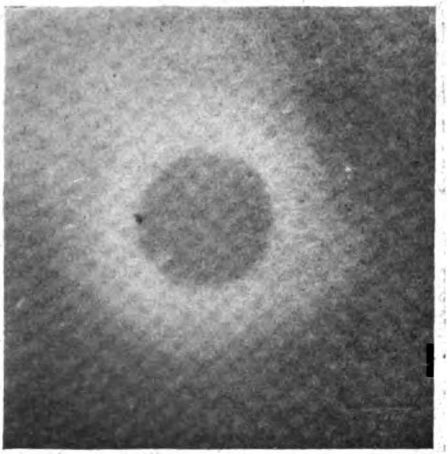

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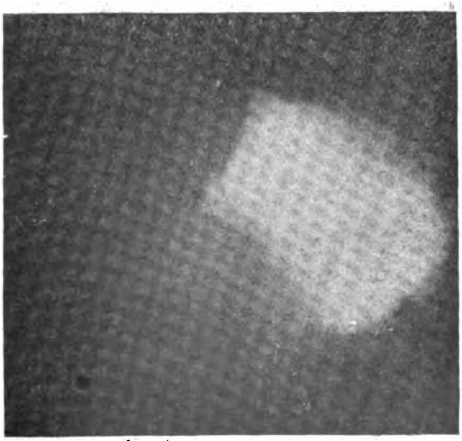

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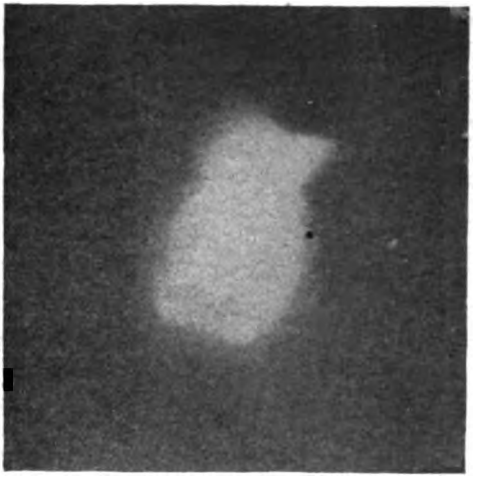

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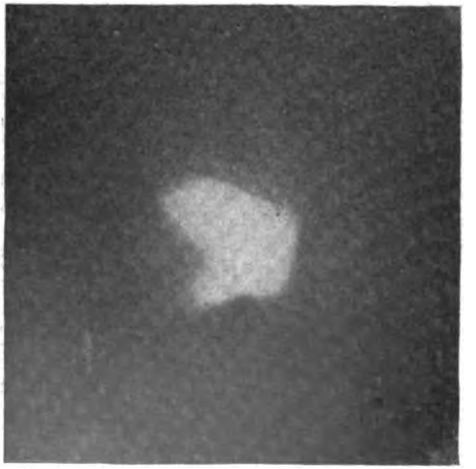

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to dissolve the uranium compounds. It is then interesting to note that the uranium may be extracted by the direct treatment of the coal with nitric acid. A sample of this "coal" from the same place, tested in Montreal, was found to be radio-active as well as the ashes it gave; this radio-activity being due to radium.

I am not able to state what is the relation between the two specimens of cleveite and "coal," but I think this fact important, and I propose to make a further investigation next summer.

The white mica vein where these specimens come from is situated near the lake "Pieds des Monts," about 18 miles back of Murray Bay, in the county of Charlevoix, on the north shore of the St. Lawrence.

NOTE.—Since the above notes were read at the meeting, I had a letter from Mr. P. Curie, of Paris, in which he says that the small piece of Cleveite from Murray Bay I sent him, shows a radio-activity equal to six times the one of Uranium, and he wants to be kept well posted about the new discoveries of radio-active minerals, in Canada.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

MR. OBALSKI—I have just given you a few notes on this subject, and I wish to present you with the specimens I have found in the province of Quebec. I may say that this may be an accidental and isolated occurrence, and I do not know what quantity may be found. I exhibit these specimens so that if any minerals of the same kind may be found by any gentleman present it may attract his attention so that he may inquire into it. Perhaps some gentleman present could say as to whether any such mineral as that has been found in other pegmatite dikes or in the Laurentian formation.

PROF. MILLER—Dr. McLennan of the University of Toronto, who honors us with his presence to-night, takes a great interest in this question of radium, and I would ask him to make a few remarks.

DR. MCLENNAN—It is only an hour ago that I heard there was anything about radio-activity going on at this meeting, and as

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soon as I heard it I endeavored to be present. I would ask Mr. Obalski if he made any measure of the radio-activity.

MR. OBALSKI—The quantity of radium in the specimen weighing 375 grammes is 1-10 of a milligram.

DR. MCLENNAN—It is exceedingly interesting to find that samples of ore so radio-active as that shown to the meeting by Mr. Obalski are to be found in this country. I think it highly desirable that in the coming summer all survey parties sent out by the Bureau of Mines of Ontario or the Geological Department at Ottawa should be equipped with apparatus suitable for testing the radio-activity of minerals. Such a piece of apparatus can be constructed very cheaply. A simple electroscope will suffice as accurate determinations can be made by means of it.

Dr. McLennan also referred to some experiments being conducted in his laboratory on radio-activity. He stated that he had found ordinary materials such as iron, lead, tin and zinc, exhibiting feeble though marked radio-activity. Quite recently, one of his students had made an examination of crude petroleum and had found that air when drawn through petroleum fresh from the well acquired an exceedingly high conductivity. Various experiments showed that this conductivity was due to the presence in the air so treated of varying quantities of the radio-active emanation from radium. A series of tests showed that the oil from one of the wells at Brantford was very much richer in this emanation than the oil from Petrolea. This might possibly be due to the oil coming from different rock formations, as the oil from the wells at Brantford was from an older formation than that found at Petrolea.

PROF. MILLER—Could you state what are some of the economic uses of radium?

DR. MCLENNAN—The only economic use for it at present is in connection with the practice of medicine. Of course, I have no experience along that line, but it does not appear to produce very satisfactory results.

PROF. MILLER—It works like the X ray?

DR. MCLENNAN—They say it has curative properties similar to the X ray.

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PROF. MILLER—It is stated that pictures can be taken with it precisely as with the X ray.

DR. MCLENNAN—It affects a photographic plate. I would suggest that you should take an old-fashioned electroscope to the field and charge it and test any specimens you may find. I might call your attention to the radio-active gas that comes from radium, and which is a very important thing, I should imagine, medicinally.

Mr. Obalski exhibited some photographs which had been taken by the specimens he presented. Of the two specimens presented he said that he did not know that the coal specimen had any radio-activity although it contained uranium.

DR. MCLENNAN—I am not a geologist but I fancy that there was an eruption where those minerals were found, and no doubt the heavier minerals would be found at the bottom.

PROF. MILLER—I do not think the Sudbury coal has even been tested for radium, but perhaps Prof. Mickle can tell us about that.

PROF. MICKLE—I do not believe that any of the samples of coal have been tested for radium or uranium. The composition of this coal seems to be quite different from that of similar coaly substances found elsewhere in Canada, unfortunately the analysis is not given in such a way that a comparison is easy, but it appears to contain much more volatile matter than the others reported elsewhere. In a paper read by Dr. Ellis before the British Association (Chem. News, 1897, p. 188), entitled, "Analysis of Some Precarboniferous Coals," the following analyses are given of the ash free substances:

	Locality.	Carbon.	Hydrogen.	Oxygen.
Anthraxolite ...	Kingston	90.5	4.2	5.5
" ...	Cap Rouge	91.3	6.2	2.5
" ...	Lake Mistassini	95.2	1.2	3.6
" ...	Sudbury	96.4	0.5	3.1
" ...	Lake Petitiskapau..	97.1	1.3	1.6
" ...	Long Island, in Hudson's Bay.....	96.54	1.33	2.13

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The last analysis is from "Science," June 27, 1902, p. 1014.

MR. MILLS—The electroscope which I am using was made with a view of seeing how cheaply a reliable electroscope for testing minerals could be made. The material consists of a portion of a coffee canister, a couple of small bits of mica, a bit of brass wire and some gold leaf; the coffee canister being cut to half its length and a square hole cut in both top and bottom; the mica being fixed over the holes so as to form windows through which the gold leaf can be seen. The wire and gold leaf were inserted through a hole in the upper side of the canister, which is fixed on its side so as to keep them perpendicular. Behind the canister is placed a graduated scale upon which the gold leaf is seen projected when one looks through the mica windows. The electroscope is charged by a few passes of a bit of fine fur against the knob of the wire. For the purpose of insulation the wire is fixed in an ebonite plug fitting tightly in the hole in the side of the canister. This electroscope has a natural rate of fall seven hundred times slower than that caused by the unit of uranium bromide so that it affords a large margin for detection of radio-activity in minerals of lower radio-active properties. My experiments have so far been of a negative character, but that was to be expected from the class of work I have been doing. However, it serves to give confidence in the results, as the electroscope shows strong action where tested with the uranium bromide unit.

MR. FRALECK—In connection with Mr. Obalski's paper I thought it might be interesting to note some occurrences of radio-active minerals in Ontario. Allanite has been found in the township of Dalton, lot 25, con. 12, also in Galway, Hagarty and Hollow Lake, Muskoka River; Columbite in Lyndoch, lot 13, con. 15; Coracite at Maimanse, and uranite in Madoc, lot 11, con. 4.

In addition to the above, a white mica in pegmatite occurs in the northern part of Frontenac county, in Sheffield, Addington county, and at Oak Lake, Peterborough county, and as this is a favorite association for radio-active minerals, these localities may prove interesting.

In Norway these minerals are obtained as a by product in

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feldspar quarrying; careful search at the quarries in Frontenac county, however, has failed to reveal them.

MR. MILLS—During the course of the next year some of our members may be near some of the localities mentioned by Mr. Obalski, and if so they might take specimens and submit them to investigation.

(The day following that on which these observations were made, I discovered radio-activity in some specimens from Cardiff township, Ontario. The rate of fall being 3½° per hour, as against a natural fall of ¼° per hour.)

MR. OBALSKI—The next time I visit the district where I found these minerals, if I happen to find another specimen I will be pleased to send it to the Toronto University.

PROF. MILLER—Perhaps Dr. McLennan could tell us what would be the value per ton of minerals running well up in radium.

DR. MCLENNAN—The sample I have is only about 1 gramme, and that cost $100, so you can figure that out.

At the close of his remarks Dr. McLennan exhibited a sample of radium of exceedingly high intensity. The sample contained about thirty milligrammes and had been purchased for him through the kindness of Mr. William MacKenzie, president of the Toronto Street Railway Company. With this radium a number of experiments were performed, such as exciting fluorescence in zinc silicate or willemite and discharging an electroscope by making the air surrounding it the conductor.

The speaker said, that in a communication from Professor Currie the latter asked whether pitch blende was found to any extent in Canada, and stated that he was exceedingly anxious to purchase some as the exportation of the ore from Austria had been prohibited.

PROF. MILLER—This second sample presented by Mr. Obalski is like what has been called anthraxolite for a number of years. I remember when coal was first discovered at Sudbury, the Toronto papers were rather hot on geologists for some time after, and one of the newspapers came out with a flaring headline, "The Country Cursed by Geologists," because "Geologists have told us for forty years that we could not get any coal in Ontario, and here is lots of it." However, it was found that this coal had little

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economic value, but perhaps it contains radium. Mr. Obalski has told us that these minerals are found in the white mica deposits in the Province of Quebec. These white mica deposits are found in great abundance in both Ontario and Quebec, and during the spring deposits of this character are to be opened up and developed in Eastern Ontario. Heretofore, white mica has been imported from India, but one of the large electrical companies in the United States now proposes to mine this mica in Ontario. A white mica industry may shortly be established here, and we may, therefore, in the future be getting these rare minerals as very valuable by products. Mr. Obalski has referred to the uranium in the ash of this coal, and I suppose it is a similar occurrence to that of vanadium in the coals of South America. The deposit to which Mr. Fraleck has referred in Renfrew county is very interesting. When that deposit was discovered in 1897 there was no economic use for columbite, and it was sold merely as specimens, but there is now a market for it, and the mining journals quote its prices. This is an illustration of the fact, that many minerals which have existed simply as scientific curiosities for years come in time to have some commercial use. Dr. McLennan has referred to the fact that radium is found in some of our petroleums, and I think it would be interesting for him to test some samples of the more recent discoveries of petroleum which have been made in Ontario. This petroleum comes from much lower levels than that which was formerly obtained and it might be that it would contain a larger amount of this element; it is a heavier oil and occurs under somewhat different conditions.

The suggestion which Dr. LcLennan had made concerning field parties is a very important one, and I think our geologists should carry with them one of these small instruments of which he has spoken.

We find graphite in numerous places, and it is closely related to the coal Mr. Obalski has shown us. It occurs at Jones' Falls, on the Rideau Canal, in pegmatic dikes and that graphite is no doubt derived from petroleum. Mr. Obalski's coal has also come from petroleum originally.

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Journal of the Canadian Mining Institute, Vol. VII.

THE EXPLORATION OF THE ONTARIO IRON RANGES.

By A. B. Willmott, Sault Ste. Marie, Ont.

Toronto Meeting, March, 1904.

For the past few years there has been considerable examination and discussion of our Ontario iron ores. The geological similarity between certain belts in Ontario and those found south of Lake Superior has been recognized. It has been claimed, especially in the old reports, that Ontario and Quebec abounded in iron ore of the first quality. Our politicians, always desirous of flattering, tell us so today. Yet the Hamilton, Soo and Midland furnaces, notwithstanding much search, have only one large producer on which to draw to-day. In 1902 these furnaces consumed 93,000 tons of Ontario ore, and were forced to buy 94,000 abroad. Still I am inclined to think that our politicians will prove right in the long run, and that our lack of ore bodies is due to the fact that we have not sought them in the right way. We have numerous surface indications, the interpretation of which it is the purpose of this paper to discuss.

Geographical Distribution.—These iron ranges are found from the Lake of the Woods on the west, to the Ottawa River on the east. Just as we have the Menominee, Marquette, Gogebic, Mesabi and Vermilion ranges skirting the American shore of Lake Superior, so we have the Mattawin, Animikie, Nipigon, Michipicoten and Batchawana ranges skirting the Canadian shore. The location of these and many others, together with notes on them, are given by Professor Miller in a report published by the Bureau of Mines for 1902. The more important seem to be the Steep-Rock-Atikokan, the Hunter's-Island-Mattawin, the Animikie, the Nipigon-Long Lake, the Michipicoten, the Hutton, the Temagami and the Eastern Ontario.

Geological Range.—These iron ranges belong with one exception to the oldest geological formations. North of Lake Superior, as south of it, three iron-bearing ages are recognized. The oldest

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is that of the Lower Huronian; following this, the Upper Huronian and the third, and latest, is the Animikie.

The only range found in the Animikie is that extending from Gunflint to Port Arthur and east. It is to be the subject of a paper before this meeting of the Institute and will not be further described here. The Mesabi, the Gogebic and the Menominee ranges of the United States, together with a part of the Marquette range, are the geological equivalents of the Animikie. These ranges produce 75 per cent. of the ore of the Lake Superior region. We have as yet no producing mine in rocks of this age. It should also be noted that the Animikie rocks are confined to a small triangular area near Port Arthur, unless the shales and tuffs within the nickel belt at Sudbury prove to be of this age.

Upper Huronian rocks are more widely distributed. The typical area is that north of Lake Huron from the Sault to Sudbury and beyond. Wherever Huronian areas are shown on our geological maps future detailed work will probably show both the upper and lower divisions. The Upper Huronian has, however, not proved prolific in iron. With the exception of the larger part of the Marquette range there are no producing mines in rocks of this age. About 16 per cent. of the product of the Lake Superior region for 1900 came from the Upper Huronian. The prospects now being worked in Deroche, and adjoining townships, north of the Sault seem to be of Upper Huronian age. So also the mine in Aberdeen township from which several vessel loads of hematite were taken a number of years ago. The hematite patches in quartzite in the townships of Long, Rutherford and elsewhere, on which some work has been done, are similar in appearance and of the same age. The ore is of high grade, but so far in small quantity. It should be noted here, for the benefit of anyone consulting American literature, that the Upper Huronian of Canadian writers is the equivalent of the Lower Huronian of American writers, they having wrongly correlated the Animikie with the original Huronian, whereas it is a later formation.

The lowest and oldest of the three iron-bearing formations, i.e., the Lower Huronian, is much the most widely distributed in

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Ontario. It has given us our only producing mine of any size; and our most encouraging prospects are in rocks of the same age. South of the line the Vermilion range is of the same age, and a few small worked-out properties on the Marquette range also belong here. In 1900 less than 9 per cent. of the Lake Superior production was of Lower Huronian origin. With the opening of the Helen the percentage was somewhat increased.

It is in rocks of this age that our main supplies will, I believe, be found. The occurrence of the iron belts, their form, composition, etc., thus become of great economic interest. In every area shown as Huronian on our geological maps, wherever in the region of the Great Lakes the green schists are found, there also have been found, or will be found, the sediments of the iron ranges. These may be small in extent, representing only the last remnants of a large area, or they may be a long and narrow belt. In no case has a band half a mile in width been found. Usually there are a series of lenses arranged for the most part in a row, or occasionally in a few parallel rows. At other times the iron belts persist for many miles, in long narrow bands enclosed on either side by green schists. The Hunter's Island and Mattawin belts are good examples. The Nipigon-Long Lake range is perhaps continuous for seventy miles. The Michipicoten range is nearly as long but is frequently interrupted.

Character of the Rocks.—The Lower Huronian rocks of the Vermilion and Michipicoten ranges have been somewhat carefully studied and may be taken as characterising the other ranges. At the base of the series in both regions there is a massive greenstone, ellipsoidally parted; this is the oldest known rock of the Lake Superior area. Overlying this is the iron formation. Later are intrusive granites, porphyries and greenstones. The whole have been bent in great longitudinal folds and closely pressed. The original sediments now stand nearly vertical. The massive greenstones have had a cleavage developed in them by pressure which corresponds closely with the bedding of the sediments. Metamorphism has so changed many of the latter that it is now difficult to distinguish some of the greenish sediments from the schistose

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greenstones. The comparatively thinly bedded sediments, when upturned on edge, make quite narrow bands in the older greenstone schists, even when doubled, as they probably are in most cases. The longitudinal folding sometimes produces one belt: sometimes several parallel ones.

In addition, a transverse folding has usually taken place, crumpling steeply the longitudinal fold. The bottom of the longitudinal fold, could we see it, in place of remaining straight has been bent into a series of hills and valleys. So also the top, but denudation has in most cases destroyed the surface appearance. Usually the hills resulting from the transverse folding have been cut down more than the valleys; in some cases until they have entirely disappeared. In the Michipicoten area the iron range hills now standing are, in many cases, the bottoms of the transverse valleys. It is in these cases useless to drill in the green schists between two iron formation outcrops with a view to finding a buried portion of the iron range.

The iron range rocks have been frequently described. They include iron carbonates, ferruginous cherts, pyritic chert, banded ore and jasper and lenses of ore and of pyrites. Banded jaspers and cherts are the most common and the most characteristic. Carbonated schists are commonly associated with the iron formation in the Michipicoten region.

Formation of Ore Bodies.—It has been conclusively proved by Van Hise and his associates on the United States Geological Survey that the lake iron ores are the result of concentration by descending waters. The source has in most cases been iron carbonate, though iron pyrite in the Michipicoten and iron silicate in the Mesabi have been important factors. Ores seem to have been concentrated in every case in an impervious basin. This, in the Lower Huronian, is usually the upper layer of greenstone underlying the iron formation which has been folded in a trough. Transverse folding has made the trough a basin. Such would appear to be the case at the Josephine and Frances in Michipicoten and at the Chandler in Minnesota, and elsewhere. It is also true of the Helen, though at this mine there is a second cause at work.

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Basins are also made by impervious layers of slate within the iron formation itself. These frequently defeat their usefulness by making several small basins instead of one large one.

Dikes cutting across the formation, particularly where a pitch occurs, frequently form one side of a basin. This is true of the Helen in part. A dike crosses the formation at right angles dipping perhaps ten degrees in the same direction as the formation pitches. As green schists undoubtedly form the bottom of the trough an impervious basin should exist on the side where they meet in an acute angle. There is some ore here beneath the bottom of Boyer Lake, how much is not yet known. The main body so far discovered is, however, on the opposite side of the dike, i.e., the dike forms the footwall. Several dikes of similar character cross the iron formation near Iron Lake. One of the best surface shows on the Michipicoten range occurs in connection with one of these.

Favorable Indications.—From a consideration of the above facts and theories regarding the formation of ore bodies we are led to the following conclusions regarding surface indications.

(*a*) An impervious basin of schist or greenstone surrounding and underlying the iron formation is favorable. This basin can frequently be seen at the ends of the shorter belts, as at the Helen, Josephine, and Frances. The central parts of the longer belts are not likely to give definite evidence on this point.

(*b*) If the basin is in the form of a pitching trough it is still more favorable. On the strength of this and other reasons drilling was carried on at the Frances and at the Josephine and ore bodies located far below the surface.

(*c*) The crossing of the iron formation by a dike is favorable, as it may chance to form one side of an impervious basin. At any rate it has promoted the circulation of water by fracturing the formation.

(*d*) Contact planes, either within the formation, or between it and other formations, are favorable, because here movement has frequently taken place and the circulation of water promoted.

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(*e*) The more broken and crumpled the jasper and chert the better, because circulation has here been good.

(*f*) The less the amount of iron in the banded jaspers on the surface, the better the prospect of finding ore in the bottom of the basin. A regularly banded jasper and hematite is not likely to have been concentrated downwards.

(*g*) The presence of any carbonate of iron is an unfavorable sign. It shows that concentration is not complete, perhaps not begun. It is true there is a large amount of siderite adjoining the Helen on the east. The ore has, however, been made, I think from what was the continuation of this hill of siderite westward over Boyer Lake. At the Josephine no siderite occurs in the numerous drill cores on the islands in the lake. Nor does siderite occur in the Frances outcrops or cores.

(*h*) A sufficient width of iron formation is necessary. One hundred feet is too narrow to yield an ore body of any size; four hundred is better. The Helen formation is over nine hundred feet; the Frances, six to nine hundred; the Josephine, two hundred and fifty feet at a depth of four hundred feet.

(*i*) The presence of impervious layers of slate, etc., in the iron formation is unfavorable. The result is to make a series of basins each one too narrow to produce any large concentration. The Michipicoten range at Iron Lake exhibits this character. No deep work has, however, been done to prove the underlying basin.

(*j*) The points where the iron ranges cross low ground are the most favorable. Van Hise states that experience on the south shore of Lake Superior shows that the ore bodies are found below the crests but above the low grounds. In Michipicoten the lowest points on the range have proved most favorable at the Helen, Josephine and Iron Lake. At the Frances there is an isolated hill of ferruginous chert rising 200 feet above a level plain. Ore has been found nearly six hundred and fifty feet below the top.

(*k*) The presence of magnetite is an unfavorable symptom. In very few mines on the south shore of Lake Superior is the

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ore magnetic. In the Michipicoten range, where magnetite is found, intrusive granites or other igneous rocks occur. These intrusives are mostly of Upper Huronian or Keweenawan age. Little concentration took place before these intrusions, and apparently none since. So also in the Mesabi range, the Keweenawan overflow prevented the formation of merchantable ore bodies in the eastern part of the range. The same condition probably operated in part of the Port Arthur district. Because an iron range is magnetic is however, not sufficient ground for condemning it. On the contrary, one of our best ranges, that of Hutton, is mainly magnetic.

Methods of Exploration.—Assuming that a given area of country is to be prospected for iron, I believe the following things should be done, and in the following order:

(1) Determine the geological boundaries of the different formations, particularly of the lower Huronian.

(2) Cross the latter, at right angles to the strike, at intervals of a mile. Wherever any indications of the iron ranges are found this interval should be reduced to one quarter of a mile. The valleys of streams should be examined for boulders of iron and of banded jasper. From a boulder found in the valley of the Magpie River I was able to point out in my first report on Michipicoten that iron rocks similar to the Vermilion range occurred in the district. A dip needle should be carried, but I do not believe it worth while to make notes of the readings, and a map unless something of value is found. Where the intervals are reduced to a quarter of a mile an attempt should be made to get complete sections.

(3) The iron range found, an accurate geological and topographical map should be made. This should show the outcrops of rock, the kind, the strike, dip and pitch, the length and width of the iron formation, dikes, if any, the position and depth of the basin, if possible. This last is a most important point, but also a difficult one. The pitch of the basin can sometimes be inferred from that of the cleavage of the adjoining schists. Again, the direction of the opening of the V-shaped banded jaspers is a guide.

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(4) Surface stripping should be undertaken while the geological map is in progress. This form of development is enormously cheaper than rock work. To say nothing of the assistance derived from it in determining the geological structure of the location this superficial work is just as likely to locate ore bodies as are shallow shafts put down at random. It is well established in the Lake Superior area that all ore bodies somewhere reach the rock surface. Surface work should uncover the contacts and other likely points for ore deposition. Rock work, because of its greater expense should not be started until thorough trial has failed to find ore at the surface. If ore is found it should be followed.

(5) If an ore body is not found and the indications are favorable, deep work must be undertaken. This will usually be the condition. A choice must be made between shafts and tunnels and diamond drilling. The latter is usually to be preferred because:

(a) It proves ground to a given depth cheaper, and

(b) It does the work much faster.

It is to be remembered also that the prospect shaft will, in most cases, turn out to be very poorly located for economical mining, and is apt to be discarded. There is a great advantage in knowing the shape and size of an ore body before locating the shaft and installing the surface equipment. This knowledge can certainly be got best by means of a drill.

(6) The location of the holes is of prime importance. The first ones are naturally directed to finding ore; the succeeding ones to determining quantity. Ore is most likely to occur along the sides or bottom of the basins and along dikes or other planes of contact. As the schists which surround our iron formations can be drilled two or four times as fast as the banded jasper it usually pays to locate holes in the schists crossing into the jasper near the point which it is desired to reach. Vertical holes, parallel or nearly so with the bands of jasper, are to be avoided. They are very expensive to drill, and the record brought from a band of ore, say two inches wide, is very deceptive. The crossing of the

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banded jaspers at a high angle is safest. To reach the bottom of a basin of unknown depth, probably the best way is to put down several holes from a point to one side, at successively higher angles. The depth to which these infolded iron formations go is surprising. At the Josephine the iron formation is less than three hundred feet wide, but it has been proved to a depth of seven hundred and fifty-eight feet below the lake level, and may go much deeper. At the Frances, the total length of the iron formation is 1,450 feet and the maximum width nine hundred feet. This short and narrow lens in the schist has been proved to a depth of over eight hundred feet, and may go further.

In both these cases ore has been found by probing for the bottom of the basins. At the Josephine there was no ore visible at the surface and the banded cherts in the islands of the lake were most impoverished. At the Frances a small pocket of ore out-cropped, which soon gave out in depth. In both cases theory said test the basins, and in both cases ore was found.

This is what I meant when I said at the start that our lack of ore bodies was because we did not look for them properly. There has been, during the past two years, some intelligent and systematic explorations of the Steep Rock, Animikie, Michipicoten and Hutton ranges. In most cases, I am glad to say, this kind of work has resulted in the discovery of ore bodies. The amount of work of this kind done in Ontario, on all our ranges together, is trifling, compared with that done on the Vermilion range alone, between Tower and Ely, a distance of twenty-five miles. The time has gone for running through the woods with a canoe and a pick. We have found our iron ranges, and in large numbers and great size. The question now is: What is in the bottom of them?

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MILLER—We are much indebted to Prof. Coleman for his kindness in reading this very important and interesting paper.

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PROF. COLEMAN—As to the work that has been done on the Hunter's Island area, there is a fair probability that we should get ore bodies there, but whether they have found anything lately I do not know.

PROF. MILLER—Last fall we received reports that important discoveries had been made near the international boundary, but I have not heard anything more definite than that. Dr. Barlow has recently been doing some of the most detailed work that ever was done on our iron ranges.

DR. BARLOW—The work with which I was connected last summer for the Geological Survey was the mapping of the Temagami iron ranges, a full account of which, accompanied by a map, will be found in the forthcoming Survey Report, which, it is expected, will shortly be issued. (Dr. Barlow showed a map of the Vermilion and North East Arm iron ranges.) The Vermilion and Ko-Ko-Ko ranges may be portions of the same belt now separated by intrusive granite. Some of the rocks belong to the lower and others to the upper Huronian. The iron formations are connected with the lower Huronian, this series being overlaid uncomformably by the conglomerates, slates and quartzites of the upper Huronian. On the first geological map, which was mainly the results of a reconnaissance of the district, both these formations were included as Huronian without a knowledge of the unconformity. We made a magnetic survey of a portion of the North East Arm iron range from the vicinity of a point about half a mile east of Turtle Lake almost to the Tetapaga River. A detailed magnetic survey was made of one mining location E. T. W. 336. For this purpose a base line was cut out approximately parallel and close to the iron range connecting the southwest and northeast posts of this mining location. At intervals of every chain a reading to record the vertical and horizontal magnetic intensity was taken, the whole being shown on a large scale map, suitably colored. Reconnaissance magnetic work was done on that portion of the iron range southwest of Turtle Lake. For this means a base line was cut out and chained, running parallel to the iron range. Offsets were chopped out and chained at every

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five chains, and these in turn were measured and the magnetic observations taken at every chain on each of these lines. By these means it was possible to trace out the belt very accurately, even across extensive swamps. The whole of the magnetic work was in charge of Mr. Erik Nystrom, a Swedish mining engineer who was kindly permitted to undertake the work for us by Dr. Haanel, the superintendent of the mines, and with the approval of the Minister of the Interior. It is hoped more of this magnetic work will be done in Canada, not only in tracing out these iron formations but in exploring for deposits of magnetite.

PROF. MILLER—This region is likely to be opened up. The new Ontario Government Railway runs very close to it, so that we are in hopes that within two or three years we shall have some shipping iron and other mines there. At least the district will be pretty well proved by that time.

We have with us this evening the head of the Crown Lands Department, which includes the Bureau of Mines in the province, and I have much pleasure in asking the Hon. Mr. Davis, Commissioner of Crown Lands, to say a few words.

HON. E. J. DAVIS—It is very kind of you to ask me to say a word or two to-night, and I can assure you that I feel somewhat embarrassed in attempting to say anything with reference to mining matters in Canada before a meeting of experts. I very well remember that a month or two after I was called on to assume the position which I now hold, I paid a visit to Sudbury. You have all heard of that visit no doubt. (Laughter.) I went there for the purpose of meeting as many of the mining men and prospectors as I could, and a public meeting was held so that I might get suggestions and information from them, having in view the objects of submitting to the Legislature at the session which was immediately to follow some changes which mining men thought would be of advantage to the province. We did have a very frank discussion on that occasion (laughter), I asked for suggestions and my wishes were complied with. I admitted that I was a greenhorn in these matters, and I felt it keenly, and I wanted to get information from the skilled heads, and the mining

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men in the district were willing to give it to me. After the meeting was over there were some things which impressed themselves on my mind, and have impressed themselves ever since. One was that there seemed to be an unanimous desire to abolish royalties, and I did abolish royalties (laughter). There was another unanimous desire, and that was that after we had amended the Mines Act, then the Mines Act should be left alone. I have done that too; I have left it alone (hear, hear). I notice on your programme that your President will read a paper on "Suggestions as to Improvements in the Mining Laws of Canada," and I hope that I will be able to be present when that paper is read, because my object is to avail myself of all the useful suggestions from expert men that I possibly can. I wish to have these suggestions, first of all, in making the laws of the province, and secondly in the administration of these laws. Representing the Mines Department of the province of Ontario, it is a great pleasure for me to-night to welcome to the city the representatives of mining interests from every portion of Canada. We are glad to have you visit Toronto, and we hope that you will aid us in the work in which we all take so deep an interest. Will you allow me to say that among the many interesting features of this meeting, there is one that impressed me from the first moment I entered this room, and that is the very large proportion of young men who are present here to-night. It seems to me that in looking forward to the future development of mining interests in this province, that is a hopeful sign, and when I say that, I am sure that none of you will think that I am in the slightest degree slighting some of those who are older. We have tried in the province of Ontario to make improvements in connection with our mining matters. I am not one of those who believe in waiting until a man is dead before you say good things of him when he deserves them, and I am sure you will all agree with me when I state here publicly to-night that we are exceedingly fortunate in this province that we obtained the services of Professor Miller (applause). You are all familiar with the good work which Prof. Coleman has done for many years (applause). Mr. Blue for many years was head

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of the Bureau of Mines, and when we lost his services we were exceedingly fortunate in getting a gentleman, in the person of Mr. Gibson, who has been a great source of help and of satisfaction to us in our sincere efforts to advance the interests of the Bureau of Mines in Ontario (applause). We are anxious that these meetings of mining men should be of an educational character, and I can assure you that the Department of Mines will aid you in your work and give you every assistance it is possible for us to give. I am glad to be here to-night, and I trust that my public duties will enable me to be present again so that I may know you more intimately, and from personal contact with you, and from listening to the valuable suggestions you make, be better fitted for the discharge of the duties of the position which I now hold.

MR. THOMPSON—Thanks to the energy of our Ontario friends, the iron ranges are being thoroughly explored, and the difficulty of getting information so as to induce capitalists to invest will soon be at an end. Mining men certainly desire to have beneficial legislation, and I was much interested in the remarks of Hon. Mr. Davis, because I feel that in British Columbia we probably have the worst mining department on this continent, and certainly the worst in this Dominion. We have always looked upon the Mining Department in Ontario as a model, and chiefly for the reason that it has adopted the policy of letting things alone. It is a good policy to follow. We have been trying to impress upon the Provincial Government of British Columbia the fact that if they would only let the mining laws alone for a little while, and let us know where we are, we might be able to get along. But, unfortunately, every year we have a new Minister of Mines who wants to do a whole lot of work, or else some members of the House who know nothing about it, suggest changes and we have got into a state of chaos out of which we have not been able to extricate ourselves.

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Journal of the Canadian Mining Institute, Vol. VII.

MAGNETIC SEPARATION.

By F. T. Snyder, Chicago.

Toronto Meeting, March, 1904.

Everyone is familiar with the simple fact that a magnet will pick up small pieces of iron. Many persons are familiar with the fact that sufficiently powerful magnets will attract a large number of materials in which the presence of iron is, at least, not in evidence, but few persons realize that the design of magnetic separators and the practice of magnetic separation has developed to a point where it can be stated that there is no material which cannot be moved by magnetism if the commercial conditions under which its movement is desired will permit of the necessary expenditure. For many materials this cost is usually prohibitive, but as a curiosity pieces of wood, apples and other things generally considered magnetically inert have been moved through distances of several inches.

In the early days of magnetic attraction, previous to half a century ago, it was generally thought that the law of magnetic attraction was simple, and even quite recently it has been stated in text-books that the attraction of a magnet for a movable particle varied directly as the strength of the magnet and inversely as the square of the distance. This, in common with the other simple laws of natural phenomena, has proved to be simple only under theoretical conditions which are not secured in practice. However, the law of movement of a free particle in a magnetic field was understood and perfectly formulated at least a half century ago. In such formula the distribution of the field is assumed as known. It is from this factor that the complications in the theory of magnetic attraction occur.

The early types of magnetic separators consisted of a straight bar permanent magnet or an equally simple electro-magnet. The material to be separated was either touched by one end of this bar

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or allowed to fall near it and in that way the magnetic was dragged out from the non-magnetic material. From this was developed numerous types of machines, similar in theory but better in mechanical form. Two troubles which developed were, first, the entanglement of non-magnetic material by the material attracted, and, second, the question of getting the attracted material off the magnet again so that the magnet could operate continuously. Most of these machines were weak and applied to highly magnetic materials only, and as the results were indifferent, the commercial growth of the industry was slow. During this time—that is, in the period of the last twenty years—the question of magnetism had come to be relatively very well understood in connection with the design of dynamo machinery, and as the necessity for magnetic concentration was urged with more and more persistency it eventually fell into the hands of competent dynamo designers, with the result that magnetic separators of greatly increased power were put into use, and from them has developed a knowledge of the design of such separators which makes it possible today to build a separator which will handle practically all materials, the limit being that the more difficult the material is to handle, the greater will be the cost of the machine, and consequently the less return commercially. This great advance in design was largely due to the conception of a magnetic field as made up of lines of force which are assumed to emerge from a polepiece of one polarity and pass through the air to a polepiece of opposite polarity. In the production of this magnetic field the conditions are very similar to those in an electric circuit, the magnetism produced being the equivalent of the current. The magneto-motive force due, in electro-magnets, to the current circulating in the windings of the coil, is the equivalent of the electro-motive force in the electric circuit, while the resistance of the magnetic circuit is analogous to the resistance of the electric circuit. It was early seen that a large portion of the cost of exciting a magnet was due to the resistance of the parts of the magnetic circuit at which the lines of force were compelled to jump through air, air having a very high magnetic resistance as compared with iron. In an endeavor to reduce this resistance, the air path was short-

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ened by bringing the magnet poles close together. In the early types of machines the material to be separated was passed through the field in such a manner that both of the poles were on the same side of the material, so that in falling the material passed through the loops of the lines of force twice. It was this looping of the lines that led to the entanglement of the non-magnetic materials, and it was this entanglement that eventually led to the abandoning of this type of machine for the type where the material to be separated passes between the poles and through the magnetic field but once, and in consequence escapes entanglement.

The freeing of material which had been attracted was at first secured by means of scrapers, and later by reducing the field at the point where the material was desired to be freed, but it is now generally obtained in the best machines by reversing the magnetism, producing a neutral point at which all material of whatever attractability is dropped. So well has the principle of the design of a magnet separator come to be understood that a difference of magnetic susceptibility now offers in many cases a cheaper way of concentrating minerals than the customary way of taking advantage of the difference in specific gravity.

From its highly attractable property and from its low value, which prevented ordinarily any other method of concentration, iron ore has naturally been a special field for magnetic separation. This has been with two specific ends in view, one the enrichment of a low-grade iron ore for the purpose of reducing the freight to a furnace and also the furnace cost of operation per unit of iron smelted. The other use has been to free the iron from deleterious materials, such as titanium, phosphorous and sulphur. Where these occur in separate crystals which can be liberated by crushing the iron ore, the resulting separation is one which frequently proves commercially feasible. In the case of sulphur, the success depends on the fact that the sulphur compounds usually found in iron, are either more or less magnetic than the iron oxides of the usual ores.

The separation of iron has divided practically into the separation of magnetites, that is, iron oxide which is naturally magnetic and can be picked up by an ordinary hand magnet, and the hema-

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tites and limonites which are less magnetic, usually so feebly magnetic as not to be attracted by a hand magnet.

As is well known, magnetite deposits lie in a great band stretching through the Appalachian Range parallel with the Atlantic coast line, from the Southern States, far north into Labrador. At various points along this line especially in New York and Pennsylvania, a large tonnage of such ores are being crushed and magnetically concentrated at present. In Canada, glacial action on the rock series carrying these ores and their subsequent grading by the waters of the St. Lawrence, has produced the high-grade beds of magnetite which have been known there so long and to so little purpose.

In the enrichment of hematites the question has divided into two different sorts of separation, one, the separation of high grade hematites from a sandstone in which they occur as a conglomerate having been deposited as detrital material from older iron beds along with the sand. The other the separation of siliceous material which was originally deposited at the same time as the iron and usually in the form of intimately entwined crystals.

The question of the physical condition of iron ore with reference to its impurities, is one of the more important in the magnetic concentration of such material. One of the first of the questions which are asked by a furnace man, when approached on the subject of iron concentrates, is the "amount of fines." If it is necessary to crush the material to such fine sizes that most of it will blow out of the top when put into a furnace, the purchase of any considerable tonnage of such material is evidently a matter to be approached with caution. Briquetting has made material advances and large experiments are being carried on at present in the smelting of briquetted iron material. Experience in briquetting has been largely acquired in connection with lead smelting and is being transferred to the older industry. It should be noted that this matter of briquetting and the production of fines is entirely a question of the physical character of the ore. Magnetic separators now handle such feebly magnetic materials as hematite in chunks of practically any desired size, separators being constructed to concentrate material up to one inch in diameter.

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The cost of building and operating a separator increases about in proportion to the size of the material which it has to handle. It is, therefore, a commercial matter as to whether the cost of briquetting or the cost of concentrating at a larger size out-weigh one another. Almost invariably it is cheaper to build a machine capable of handling larger sizes than it is to briquette, as in general, briquetting costs more per ton that the cost of separation, including interest, depreciation and royalties on the separator when handling material as large as one inch in diameter.

In such a matter as the St. Lawrence iron sands, where the material is already crushed, and generally crushed even finer than enough to free it from the accompanying gangue, the question of briquetting is an important one and bears an aspect which should interest Canada with its water powers. The need of briquetting iron ore for use in a smelting furnace is brought about by the high pressure of the modern blast. If this blast could be eliminated, within certain limits, it would be a matter of indifference as to whether the material was coarse or fine. It would still have to be granular enough to permit the escape of the gases generated in the smelting operation. Electric smelting provides just the required condition that there need be no blast. The magnetites, being iron oxides, need only be mixed with carbon in the shape of any clean fuel, such as coke or charcoal, and subjected to the heat generated by an electric current to have the carbon join with the oxygen of the magnetite and escape as carbon monoxide, leaving the iron to be tapped off in the form of pig. These St. Lawrence magnetites could probably be dredged up and concentrated wet into an iron ore of unusually high grade and delivered in the Ottawa valley for a cost not to exceed one dollar per ton. Their commercial utilization by means of magnetic separation would appear to offer the promise of a very considerable industry when taken in connection with smelting by means of the water power now going to waste in the Dominion.

Of next importance commercially from the standpoint of magnetic separation is the separation of the mixed sulphides of lead, zinc and iron. This so-called "Leadville problem" has existed for many years. There was in this camp a large tonnage of zinc-

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lead ore which was too high in zinc to permit the lead furnace man treating it without getting into serious difficulty through the choking up of his stack from zinc accretions and too high in lead and iron to permit the zinc smelter from treating it without the destruction of his retorts through slagging by lead and iron. The specific gravity of the zinc and iron was too close to permit of commercial water separation. Through zinc interests, who were looking for an additional supply of zinc ore, this problem was attacked along the lines of magnetic separation and in its solution was secured much of the data which now forms the basis for an established magnetic separation industry. A parallel problem existed at Broken Hill, in New South Wales, Australia. Here the lead and zinc were so intimately mixed that when crushed to the proper mesh for separation, a large amount of the lead was lost by sliming and the zinc concentrates which were secured were too low in grade to stand the freights to a European smelting point. Here, as at Leadville, the introduction of magnetic separation has resulted in the utilization of a very large tonnage of what was heretofore waste material. In British Columbia there exists a similar problem, awaiting the enterprise of the Canadian interests, to take up the matter of handling it magnetically. It might be pointed out that there exists two different ways of handling this problem. The mixture of zinc and iron sulphide may be roasted to reduce the iron sulphide, which normally is almost entirely non-magnetic, to a form of a highly magnetic sulphide, or it may be roasted further to bring the iron to the condition of a magnetic iron oxide, in either of which conditions it may be removed as the magnetic product. Operating in this way the cost of roasting is involved and the additional loss due to the fact that if such roasting be deferred until the zinc smelter is reached, the sulphur can then be utilized in the manufacture of sulphuric acid. At Leadville and at Broken Hill the ore is not roasted, it being the zinc that is pulled out as the magnetic product, the iron sulphides remaining behind as the non-magnetic product. There is reason to think that this would be the better commercial way of doing it in British Columbia in those cases where the zinc sulphite is sufficiently ferrugenous to permit it. Such is usually the

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case where the zinc is black, or as the miners speak of it, "Black-jack."

Third in commercial importance has been the separation of manganese. Manganese, as generally known, is used in the manufacture of Bessemer steel, to which it is added in the form of ferro-manganese or speigeleisen for the purpose of reducing the oxides which may be formed by overblowing the charge. For the purpose of making ferro-manganese the commercial requirements are for an ore that carries 50 per cent. of manganese. The tonnage of ores of this class is rather limited, while there is an enormous tonnage which carry from 5 to 15 per cent. of manganese. This is too much manganese to permit the ore being used as an iron ore, and it is not enough manganese to enable the ore to be used for the production of ferro-manganese. The magnetic separator enables the owner producing material of this character, to separate it into two products, one a 50 per cent. manganese ore, and the other an iron ore carrying two or three per cent. in manganese, so making out of an unsalable product, two products, both of which find ready sale. In this separation either the manganese or the hematite may be the more magnetic product, depending on the local peculiarities of the ore handled.

The magnetic separation in which Canada is especially represented is the cleaning of corundum. A commercial sample of Canadian corundum purchased in Chicago was found to contain something over 10 per cent. of magnetite. Passing this over a magnetic separator, the magnetite was reduced below 3 per cent., the change representing an increase in the corundum contents from 89 per cent. to 97 per cent. Further experiments along this line seem to indicate that if desired, the iron could be sufficiently removed from the aluminum oxide to render corundum a commercial ore for the smelting of aluminum. Incidentally in this connection the separation of hornblende from corundum, magnetically, has proved to be of advantage.

The attractability of hornblende has been utilized in connection with the concentration of metallic copper. In ores of this character the gangue, which was almost entirely hornblende, was pulled away as a magnetic product from the copper, leaving a

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copper ore which was sufficiently rich to smelt directly for copper, although the original ore carried less than 1 per cent. of copper.

Another interesting separation has been the handling of mica as a magnetic product. This may be utilized in two ways, for the extraction of mica from other material as an impurity and also for the concentration of mica for use in making mica insulating materials.

Of all recent developments of the magnetic separating methods, the more important is the fact that the cost of such separation is now generally below that of the equivalent water concentration, so that even in cases where water concentration is particularly adapted technically, as in the separation of chrome ores from serpentine, the magnetic method still proves the better commercially. It was this very low cost of magnetic separation that enabled concentration to succeed in the enrichment of hematite after water methods had failed commercially. One fact of advantage in magnetic separation is that it can be made, as desired, either wet or dry. It occasionally happens that the freight on moisture contained in ore in shipment to a smelting point, is a sufficient item to warrant drying it. In this case if the ore is reasonably dry as it comes from the mine, the magnetic separation can be made dry, saving the cost of drying. On the other hand, if moisture in the ore is immaterial, either from freight considerations or from the smelter's standpoint, and it occurs in a wet mine, it is possible to put it through the magnetic separator without drying, shipping the product as it occurs. This is of especial importance in connection with the St. Lawrence magnetite sands. The cost of drying that material before separation would probably prohibit its commercial utilization. As it is, such sands can be dredged up by any economical form of suction or dipper dredge and sluiced through a machine with an adequate supply of water, and produce a high grade iron concentrate which can be drained to less than 15 per cent. of water without artificial heat.

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DISCUSSION.

PROF. MILLER—Mr. Snyder is possibly one of the young men to whom Hon. Mr. Davis has referred, but I may explain that I have known Mr. Snyder for a number of years, and he looks just as young as when I first saw him.

There are a number of gentlemen present who have done some interesting work on magnetic separation, but before asking them to discuss this paper, to use a slang phrase, it is up to Mr. Craig to explain why this Canadian corundum which was advertised to run 99.5 per cent. pure is found, when it reached Chicago, to contain 10 per cent. magnetite (laughter).

MR. B. A. C. CRAIG—I do not want to go into too great details in explanation, but I may say that for some time I have been hearing of the machine which Mr. Snyder in his modesty has made no mention of, viz.: the Snyder Magnetic Separator, and I think it will probably in the future occupy an important position in the field of magnetic separation. Before Christmas I took a trip to Chicago for the purpose of seeing this separator and testing its working. For some time past I have had occasion to look into the question of magnetic separation, and to examine into the workings of different magnetic separators. I do not know that it is wise for me to enter into details but possibly my opinion on the Snyder Magnetic Separator above stated may be interesting.

MR. OBALSKI—I am much interested in this paper of Mr. Snyder's. He has referred to our magnetic sand on the north shore of the St. Lawrence, and if we can get a perfect concentrator it will be a valuable thing for us. The black material that Mr. Snyder refers to is very likely ilmenite or titanic gross, and what we want is to get rid of the titanium. If Mr. Snyder's machine can be adapted to our sand, and if it handles a very large quantity of material it will be a great thing for us.

DR. PORTER—Perhaps I may be permitted to congratulate the meeting upon the very admirable exposition of the history and general princples of magnetic concentration which Mr. Snyder has presented to us. He has reviewed the story of magnetic concentration most admirably, and with an unnecessary degree of

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modesty he has omitted to mention his own machine. Without in the least detracting from the great value of what Mr. Snyder has done, it is safe to say that there are other machines which accomplish the same object as his does. As to the sands in the lower St. Lawrence, I have examined sands from a number of different points and I found that they contain magnetite, with titaniferous material, garnet, sometimes rutile in small quantities, and silica, and other things which are non-magnetic or less magnetic. The separation of the magnetic material from the non-magnetic is not very difficult, but the difficulty is to separate the magnetite. I am speaking now of the scientific and not the commercial difficulty. The difficulty is to separate magnetite which would be low enough in titanium to be satisfactory blast furnace material. It has only been done on sands in a few localities. I have found in my own experiments sands from one or two places which can be fractioned into magnetic iron ore which is reasonably titanium free. The slightly magnetic titanium material and non-magnetic sands are presumably worthless. This material is extensively found and even if it can be separated other difficulties follow. I have not the least doubt that the problem will be solved, but for the moment the difficulty is to separate by magnetic separation, unless we can get a fractioning of the titaniferous from the magnetite material. It would be interesting to the members of the Institute to be reminded that there are a number of other separators which are important from a commercial point of view, and that there are others which are promising. It has been found quite possible by magnetic means to very highly concentrate some of the Sudbury nickel ores. Whether that is capable of commercial application has yet to be determined, but some of the Sudbury ores can be concentrated by the removal of the pyrrhotite, leaving the non-magnetic residue containing perhaps five or six times as much nickel and cobalt as the original ore.

DR. BARLOW—Recently some experiments were carried on under my instructions by Mr. W. M. Ogilvie in the mining laboratories of McGill University, and with the kind permission of Dr. J. B. Porter. The work was done under the auspices of the Geological Survey Department. Some of the concentrates ob-

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tained after a single trial with the Wetherill magnetic separator showed a feebly or non-magnetic product containing 30.41 per cent. to 30.36 per cent. nickel. Analyses of these portions showed them to consist in one case of 1 part of chalcopyrite and 21 parts of pentlandite, and in the other case of 1 part of chalcopyrite to 7 parts of pentlandite.

The nickel was in every instance present as a distinct and separable nickel-iron-sulphide (pentlandite) and not, as many suppose, as an essential constituent of the pyrrhotite, replacing isomorphously an equal amount of iron.

These experiments were rather disappointing, for although a good separation was easily and economically effected, the total amount of nickel present in the magnetic portion or "tailings" which usually constituted 75 to 95 per cent. of the whole mass was too large to be neglected. The assay value of this magnetic portion was of course proportionally very much less than that of the non-magnetic portion, which, as shown above, was in some cases almost as pure pentlandite. Future experiments which it is hoped will be carried out, may suggest some means of saving this nickel, as it is well known small changes in the strength of current make considerable differences in the results.

In various parts of Canada there are large deposits of pyrrhotite carrying different amounts of nickel, sometimes as high as 1 per cent., and it is confidently expected that in these cases it will be possible to separate a highly nickeliferous product in such amounts as to be of economic importance.

DR. PORTER—The work done in McGill University has shown that it is quite possible scientifically, and I trust it will prove so commercially as well. Another point Mr. Snyder mentioned might have been made a little more prominent. One difficulty in magnetic separation is that much of the stuff has to be made very fine. It is very desirable, particularly with iron ores, to have the resultant product of the magnetic separation coarse enough to go into the furnace without briquetting. The hematites and jaspers, and so on, get concentrated if crushed at 10 mesh, but in that operation you produce 50 per cent. which is finer than 20 mesh, and which the blast furnace people do not want. If it is

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necessary to crush to any particular size in order to get magnetic separation, the product produced will be very fine. Unfortunately in a great many of the specimens which are brought to us for investigation in magnetic separation, we find not merely a crushing of 10 mesh but a crushing of 100 mesh is essential before a really satisfactory separation can be effected. I have mentioned this, not to belittle the importance of magnetic separation, but merely to accentuate one of the difficulties that is in the way of the student or practitioner in this particular form of separation. I again thank Mr. Snyder personally for what he said, and I am sure the Institute will join me in subscribing to the statement, that in a great many instances more than we now realize, magnetic separation has displaced gravity separation. We are only in sight of the very beginning of this process.

MR. GIBSON—In common with the rest of the meeting I have listened with pleasure to Mr. Snyder's lucid explanation of magnetic concentration. I would like to ask him if he has had any experience or is he aware of any actual practice in the concentration of magnetic ores high in silica, such as our magnetite interbanded with jasper, or what are known as lean ores of any other type? Have any practical difficulties been encountered in such concentration, whether through the presence of impurities or other causes; and what is the cost of such concentration?

MR. M. B. BAKER—There is a deposit about 15 miles back of Napanee that is of interest to Ontario. This ore, which is chiefly pyrrhotite, with some iron pyrite, mica and hornblende, carries 2 per cent. of molybdenite and it has been tried in the Kingston school to separate this material by ordinary gravity methods, but it was not successful economically. Then magnetic separation was tried. The ore was first crushed and screened, the mica and molybdenite came out as flakes, and then the undersize was passed beneath the separator and a weak current took out the pyrrhotite, which was the most strongly magnetic in the gangues. Then the strength of the current was increased, which took out the mica; then it was altered a third time and took out the hornblende, and it was then heated on tables to separate the non-magnetic iron pyrites from any undersize molybdenite that

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passed through the original screening after crushing. Here is an ore that carries a fair percentage of molybdenite, and I would like to know what is the best method of treating it.

MR. SNYDER—Among the many things which have been tried was to put a separator in a tank and let it run under water, and the first thing that happens is that the falling of the material through the water is so slow that the method becomes impracticable commercially. A number of other methods have been worked out. The Government of New South Wales, in Australia, offers a very substantial reward for a process of wet magnetic separation. There have been thousands of dollars spent in efforts to get a wet magnetic concentrator. To-day there are three different wet machines. We have one which has been fairly satisfactory, and there are two others. We have four different types of wet machines for different conditions, one being a machine capable of meeting the conditions of the St. Lawrence sands with a capacity of 1,000 tons in 24 hours. The cost of operation is a very small quantity so far as the magnetic separation is concerned.

In regard to the Sudbury separation, about two years ago we jumped into it and we were very enthusiastic over it because we found it worked. I had the pleasure of taking the matter up with Mr. Turner some few months back, and we found that while our method worked well technically, it would not pay commercially, and so we lost our interest in it. The conditions are such that magnetic separation there, though it was eminently successful, would not pay. It can be worked technically, and if people were less fortunately situated than the Canadian Copper Company, they might find it of value. If the ore was lower in copper the condition might be different.

When we started with the hematite ores it promised well. We find now that we can sell any tonnage of ore we produce which does not run over 10 per cent. through an 80 mesh current. The 80 mesh ore will stay in the modern furnace. But in cases where the cost of crushing becomes the prohibitory item, we find that the question of fineness drops out entirely. In regard to the concentration of magnetite from silacious material there is a considerable amount of that type of ore in the United States. We

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find no difficulty at all in separating the magnetite. We find we can separate this material so fine that it is practically without grit. The cost of the magnetic separation itself is an unimportant item. The cost of crushing depends on the size to which the material has to be crushed, and our experience is that the cost of crushing in the average community is about 1 cent per mesh—60 cents per ton for 60 mesh—20 per cent. for 20 mesh and 10 cents for 10 mesh.

It has been said that molybdenite is not magnetic, but we have been quite able to pick it up magnetically by using sufficient magnetic power.

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Journal of the Canadian Mining Institute, Vol. VII.

Student's paper, submitted for the Prize Competition.

NOTES ON THE OCCURRENCES, PRODUCTION AND USES OF MICA

By E. T. Corkill, Queen's University, Kingston, Ontario.

Toronto Meeting, March, 1904.

The essential characteristic of the mineral known as mica is its highly perfect basal cleavage, permitting the mineral to split as thin as one hundred thousandth of an inch; further it is tough and more or less elastic. Mica crystallises in the monoclinic system as tabular or short prismatic crystals. Its power of resisting the action of high temperature, and being a non-conductor of electricity unite to place mica in an unique position of utility and give it an exceptional commercial value.

The micas are silicates of aluminum, the alkalies and magnesium in varying proportions. Alterations in chemical composition cause changes in the physical properties and so affect the commercial value of the mineral and consequently only the varieties known as muscovite and phlogopite and in a lesser degree biotite are commercially valuable.

Muscovite, commonly called white mica, is usually found colorless, but is also pale green, yellow and ruby color, and in some cases is deeply tinged by inclusions of ferruginous matter. It is mainly an orthosilicate of Al. and K. containing a small per cent. of water, according to the following percentage:

SiO_2	= 45.2	per cent.
Al	= 38.5	"
K	= 11.8	"
H_2O	= 4.5	"

The ruby mica of Hogaribagh, Bengal; the olive green of Nullore, Madras, and the ruby of Brazil are all muscovite.

Phlogopite, the amber mica of commerce, is generally yellowish brown in color, though it may become nearly colorless. It is

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essentially a silicate of magnesia and alumina containing a little iron. A typical phlogopite gives the following analysis:

Al_2O_3	= 17.	per cent.
Fe_2O_3 and FeO	= 5.	"
MgO	= 26.5	"
K_2O	= 10.	"
H_2O	= 3.0	"
F	= 2.2	"

The greater part of our Canadian mica is phlogopite.

Biotite, usually called black mica, is also a silicate of magnesia, but contains considerable iron. A chemical analysis gives:

SiO_2	= 39.5	per cent.
Al_2O_3	= 16.5	"
FeO	= 8.5	"
MgO	= 22.0	"
K_2O	= 7.8	"
H_2O	= 4.0	"

The photograph below shows a crystal of biotite from the Chibee mine, Quebec.

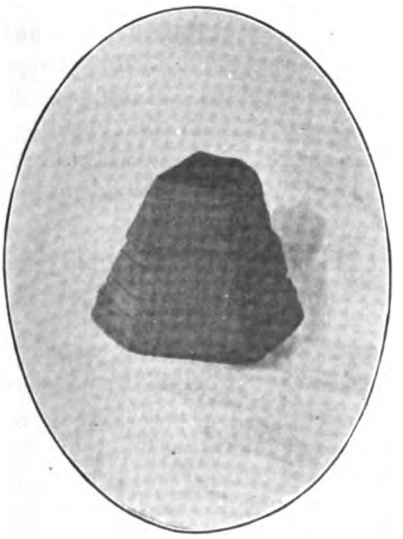

FIG. 2.—Biotite from Chibee Mine, Que., showing crystal form.

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Modes of Occurrence.

The three principal mica producing countries in their order of importance are:—(1) British India, (2) Canada, (3) United States of America.

India has until the present produced about 50 per cent. of the output of the world. The occurrences of marketable mica in India are practically confined to the two districts in the peninsula, via., Bengal and the Madras Presidency. The Indian Peninsula is composed chiefly of the upper divisions of the Archean crystalline rocks, as the mica and hornblende schists and quartzites. Outside of this peninsula as in the Himalayan range, the rocks are crumpled and folded, while the peninsular rocks have remained firm and compact since at least the lower paleozoic age, and as a result many old rocks as the pegmatites, have been preserved in their original state. In these undisturbed pegmatite dikes we find the mica occurring. These pegmatites are composed chiefly of quartz, feldspar and mica. It is thus evident that the pegmatite is simply a coarse-grained igneous or aqueo-igneous rock in which the mica crystals are large enough to be of commercial value. In Ontario we have similar pegmatites in which feldspar is the commercial product. An example of this is seen in the Richardson feldspar mine near Bedford. Many accessory minerals have been found in these pegmatites, as albite, apatite, beryl, cassiterite, flourite, garnet, magnetite, topaz, wolframite, minerals of the columbite group, uranium mica, molybdenite, spodumene, tourmaline and a host of others.

In the Bengal Presidency, which comprises the Gaya, Hazaribagh and Monghyr districts, there have been over 250 mines opened, turning out annually about 450 tons of mica. In this region the pegmatites are abundantly developed in the schists where the so-called "dome gneiss" is prevalent. This "dome gneiss" occurs in large roughly lenticular bosses of granitite as well as in thin sheets intruded between the schist foliae. The pegmatites are thus supposed to have been formed from the end products of the magma whose earlier eruptives produced the "dome gneiss." Apatite occurs in several localities as a by product. This district produces the ruby-tinged mica.

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In the Nellore district in the Madras Presidency, the schists with their included pegmatites are found in the low-lying plains and are thus concealed by recent formations. The pegmatites are usually in the form of intrusive sheets or dikes following the foliation of the schists, very rarely cutting across the foliae. They are most frequent in schists dipping at high angles. The muscovite in this district varies greatly in color, white, smoky, and grass green and yellowish green varieties being obtained. In Madras Presidency in 1902 there were 69 mines in operation, employing 2,965 persons and producing 228 long tons.

Although mica has been mined here for many years the methods of working are still of the most primitive character, even the unwatering of many of the pits being done by hand labor which is very cheap, the men getting three pence and the women one and one-half pence per day.

The commercial deposits of the United States extend along the Appalachian system of mountains, chiefly in New Hampshire and North Carolina and to a lesser degree in Maine, Virginia and Georgia. The Black Hills of South Dakota also furnish some mica. The mica is found in coarse pegmatite dykes and these in turn occur in the granite or gneissic rocks and the hornblende and mica schists. The area covered by the crystalline rocks in which the deposits of mica occur is great. These crystalline rocks form the backbone of the Appalachian system of mountains from Maine to Alabama, and they are also found in areas in the Black Hills, Rockies and other mountain districts in the West. This mica-holding area bears the same relationship to the contorted and folded Appalachian range that the Indian peninsula holds to the Himalayan chain.

The pegmatite dykes are usually white in color owing to the quantities of quartz and feldspar, and vary from a few inches to several hundred feet in thickness. They are irregular in outline and frequently have short irregular branches extending into the country rock. Some are parallel to the bedding or laminations of the gneiss and schist, some horizontal, while in other cases they cut across the laminæ at various angles, as in the case of true

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fissure veins. As a rule the pegmatite dykes have no distinctive banding, laminations, or any other regular structural features such as we find in true fissure veins. Clay selvage has been observed between the dykes and country rock, but in the majority of cases the contact is clearly defined without the presence of selvage. Where the dyke cuts across the gneiss, quartz and feldspar are found impregnating the country rock for several feet. Fragments of the wall rock are sometimes found embedded in the dyke material.

The general theory advanced for the origin of these pegmatite dykes is that the material of which the dykes are composed was forced up from below in the form of an igneous magma. Most, if not all, igneous magmas contain water, and acid magmas are inclined to be particularly rich in this material and as in the process of crystallization anhydrous minerals are separated, the water becomes concentrated in the residuary mother liquor, which can thus remain fluid at a much lower temperature than the original magmas. The aqueo-igneous magma under pressure was forced along the lines of least resistance as the bed or laminæ of the schists. These rocks were heated by the injection of the molten magma and consequently there was a very slow dissipation of heat. The reduction of temperature was still further retarded on account of the great specific heat of the water contained in an aqueo-igneous melt. The water which becomes concentrated in the magmas that form our pegmatites explains the high degree of fluidity and consequent injections to great distances of very thin films as well as the remarkably well crystallized condition in which such thin dykes of pegmatites are invariably found.

J. A. Holmes gives the following laws for the occurrences of deposits of commercial mica. Mica is likely to be found:

1. In regions where the country rock is either mica schist, hornblende schist, or a somewhat schistose gneiss.

2. In such of these regions where the crystalline schists and gneisses contain numerous fairly large and coarsely crystalline pegmatite dykes.

3. In a region where these pegmatite dykes have not been greatly crushed or sheared in connection with great earth move-

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ments, such as accompany and result in the formation of mountains.

4. Where on some portion of the exposed surface of these dykes occasional blocks of good mica may be observed several inches in diameter, the outlook may be regarded as favorable to development. It is a rule that has been fairly assumed that when along the surface of one of these pegmatite dykes which is exposed for considerable distance, no large crystals are observed none are likely to be found at greater depth.

5. If mica is ruled and speckled with iron after considerable excavation, these defects will likely continue in depth.

Mica is mined in Canada principally in Ottawa county, Quebec, and Frontenac and Lanark counties, Ontario. Deposits have also been observed in the township of Methuen, Peterborough county, occurring in syenite dykes associated with corundum. The mica, which is muscovite, is as a rule too hard for electrical purposes and the deposits have as yet not been developed to any extent. A deposit of muscovite has been found near Massanoga lake, Effingham township, county of Lennox. This deposit from surface indications appears to be quite considerable in extent. It is therefore quite probable that commercial quantities of muscovite will yet be found in Ontario.

As is shown by the accompanying map the chief deposits of mica in Ontario and Quebec occur in the granitic and gneissis rocks and crystalline limestone of Archean age. The southern extremity of the mica belt (shown on sketch map) is in the townships of Loughboro and Storrington, near the contact between the Silurian and Archean. This belt extends north through Bedford into Lanark county, where it crosses South Sherbrooke and North and South Crosby into the township of North Burgess. This township is a very important producer of mica. Between Perth and Ottawa the Archean formations are overlaid by Cambro-Silurian rock and consequently no mica deposits have been found. In the northwestern part of Carleton county in the townships of March and Huntley, we find the granite and gneiss again out-

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cropping. Some mica deposits have been found in this but it is biotite and of not very good quality.

North of the Ottawa River in the county of Ottawa, Quebec, along the bank of the river, the calciferous and chazy formations overlie the Archean. North of this the area for the most part is occupied by gneiss and granite with occasional areas of crystalline limestone. In this area we frequently find dykes or masses of pyroxene in which the mines of mica are found. The most productive mines in this district have been found chiefly between the Gatineau and Lievre rivers.

Prof. W. G. Miller divides the rocks of this district into four classes:

1. The oldest consisting of crystalline limestone and associated dark gneisses.

2. The crystalline limestone and gneisses are cut through by granites, syenites, etc.

3. Numbers (1) and (2) are cut through by trap dykes, such for example as the columnar dykes on the Rideau which have their counterparts in the districts further west. These dykes were probably connected with surface flows.

4. All these series are overlaid by Potsdam sandstones and Silurian limestones in certain areas. In the county of Ottawa, Quebec, the Paleozoic strata are sometimes cut through by igneous rock.

In this belt we do not find mica occurring in pegmatite dykes as is commonly the case in other parts of the world. The deposits of Ontario are unique in this respect that they occur here as veins.

Some of the veins are bedded, in part filling crevices corresponding in strike and dip with the gneiss. Others are found having the same strike as the gneiss but cutting across the layers almost perpendicularly. In some cases the borders between the gneiss and vein are sharply defined, while in other cases, especially where vein formation of the nature of "pyroxenite" borders on the gneiss, the contacts are indefinite. This is caused by impregnation of the gneiss with vein material. Some of these veins show

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layers parallel with the cleavage planes of the gneisses, a structure well known in ore veins. Angular fragments of country rock have been found in the veins. Druses are found, the walls of which are lined with well crystallized vein mineral. Thus in all respects these deposits present the characteristics of fissure veins.

FIG. 1.—Banded structure of pyroxenite. Lacey Mine.

Four minerals constitute the vein matrix, pyroxene, apatite, phlogopite and calcite. These four are not always present but we generally find pyroxene and phlogopite occurring together. These veins are usually accompanied by a rock called "pyroxenite." The rock here designated by the general name of "pyroxenite" is mainly an altered gabbro with secondary vein fillings which

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are connected with the formation of the mica and apatite. In petrography we understand pyroxenite to be a primary plutonic rock consisting almost exclusively of members of the augite family. This "pyroxenite" is held by Dr. Ells to be probably derived from igneous sources either as submarine injections while the Laurentian rocks were being formed, or as subsequent intrusions even though at present they exhibit much the character of bedded rocks. These intrusive rocks are stated to belong to the family of the gabbros. Dykes of gabroidal rock sometimes do occur near the veins, but the "pyroxenite" bordering on the veins is usually formed by the impregnation of the wall rock by the vein material. This transition of the "pyroxenite" into the gneiss is referred to by Osann and Penrose. "The pyroxene rock is never found distinctly bedded, but when a vein is deposited conformably between gneiss strata its own layers must naturally be parallel with the cleavage planes of the gneiss." This is illustrated by the accompanying photograph of the "pyroxenite" from the Lacey mine. Sometimes the pyroxenite contains irregular pockets of apatite and phlogopite. From these irregular masses run off veins widening in places, which are often filled with crystals of mica. The walls are sometimes penetrated with a perfect network of these veins or the whole "pyroxenite" is impregnated with apatite and mica. Here it is difficult to determine the boundary between the altered plutonic rocks and the later formed "pyroxenite." The irregularity in structure and modes of occurrences may be due to the great crumbling or pressure to which the rocks have been subjected and which may in some cases have occurred subsequent to the formation of the vein itself.

In the accompanying diagram, No. 2, I have drawn a section through the Lacey mine (which is the largest producer of mica in Ontario). We see from this that the vein material of calcite and phlogopite with a few crystals of pyroxene and apatite is bordered by the "pyroxenite." In diagram No. 3 we have a section through the mine parallel to No. 2, and 75 feet southeast of it.

From these diagrams it is quite evident that the vein forks, and at the juncture of these veins there is a chute of mica or

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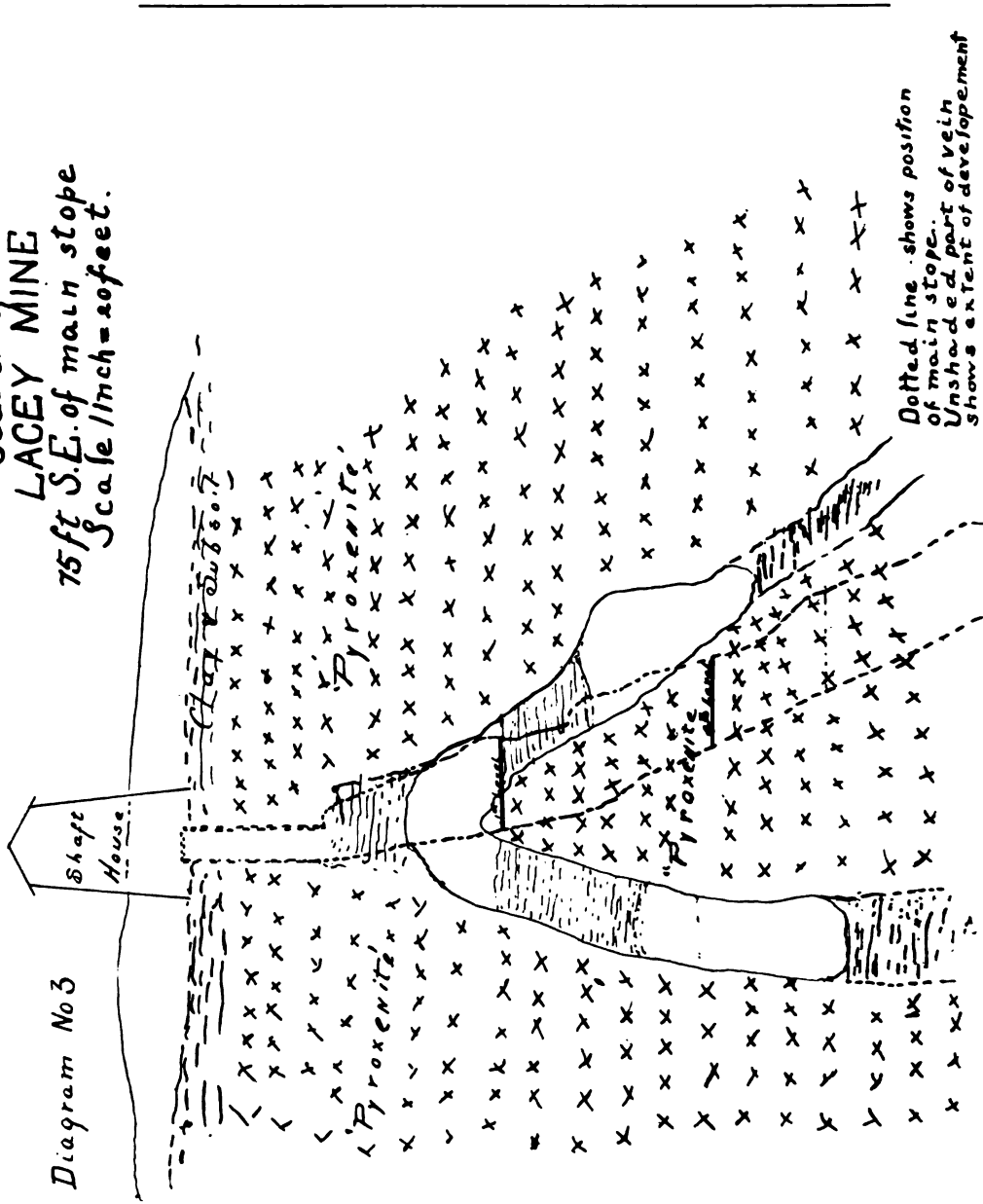

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concentration of values. Here there is but little gangue, the mica crystals reaching from hanging to foot-wall. The rock between these veins consists of "pyroxenite." This segregation of mica in chutes is very common in these deposits and forms another point of similarity between its occurrence and that of ores in fissure veins. In regard to the contention that these mica deposits are only superficial, I may state that these veins are exactly similar to the apatite deposits of Ontario and Quebec. At a number of apatite mines in Quebec a depth of 500 to 600 feet has been obtained, where the prospect for successful mining is apparently as good at the bottom as near the surface. On account of the highly destructible nature of mica the movements of the rocks may cause it to be so crushed and folded at this depth as to be worthless as sheet mica. As far as has been observed in a number of workings the supply of mica has not ceased with depth, but so much of it was worthless on account of its being crushed and folded that the mining of it was not commercially successful. We might then say that just as some metallic ores have simply a commercial wall, mica has simply a commercial depth.

In the mica from the Lacey mine we find the typical phlogopite having the following chemical composition:

SiO_2	=	39.66	per cent.
TiO_2	=	56.	"
Al_2O_3	=	17.	"
Fe_2O_3	=	27.	"
FeO	=	20.	"
MgO	=	26.49	"
BaO	=	0.62	"
Na_2O	=	0.60	"
K_2O	=	9.97	"
H_2O	=	2.99	"
F	=	2.24	"

This mica is found well crystallized, some of the crystals being as much as seven feet in diameter. In addition to this, what is commonly called "milky" mica is found. The milky mica is a steel gray color while the typical phlogopite is brown to amber in color. I examined both these grades under the microscope and found that the axial angle in both the micas was the

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same. A six-rayed star is shown in the percussion figure, the cracks intersecting at the centre of percussion at angles of sixty degrees approximately. The ray which lies nearly parallel to the clino-pinnacoidal plane (i.e., the plane of symmetry) is called the leading ray. This in both micas lies parallel to the plane of the optic axes. This proves both micas to belong to the second order. The "amber" mica (typical phlogopite) shows absolutely no asterism while in the milky variety the asterism is very noticeable. Under the microscope it also appears full of microscopic needles that lie at angles of sixty degrees to one another and are arranged with great regularity through the crystal. In parallel polarized light these needles appear black, but under crossed nicols have very high refraction appearing like lines of strong white light. They also have parallel extinction. These inclusions are therefore in all probability rutile. These crystals are not observed in the clear phlogopite. In the chemical analysis given for amber phlogopite .56 per cent. Ti. is present, but in the "milky" variety a higher per cent. is found. The rutile is therefore a secondary constituent of the phlogopite due to a segregation of Ti. by secondary alteration. The milky mica is quite brittle and does not split as readily as the amber, though its insulating properties appear to be unaffected.

A few general points may be summed up as noteworthy:

1. That the veins are in some cases sharply defined and deposited in a series of fissures striking across the rock in various directions.

2. That the character of the vein material is such as is usually found in fissure veins, sometimes presenting a banded structure due to the apatite and pyroxene forming in layers.

3. That both rocks and veins most probably received their charge from some common deep-seated source by hydrothermal action probably deep beneath the surface where heat and pressure were sufficient to allow of the apatite and other minerals in the veins being deposited by water.

4. The surface of some of the crystals present traces of hydrothermal action in their rounded angles and honeycombed surface.

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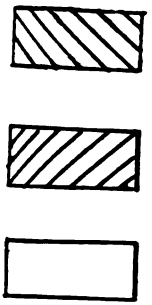

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5. That the vein was in a state of movement while in plastic condition is shown by the distortion of the crystals of mica in some deposits without the rupture of the vein stone.

Methods of Production.

The mining of mica has not as yet in any part of the world, with possibly the exception of a few mines in Ontario, been placed on a systematic working basis. Investors in mica mines are not content simply to make the usual profits realized in metal mining, but if they cannot double their money in a short time they will cease operations with the cry so often heard, "It doesn't pay." Until this has ceased we cannot expect mica mining to take the place in the mining world which it deserves. The greatest cause for many of the mines (or rather workings) "playing out" is the lack of systematic development work along with the extraction of the material. The General Electric Company of Schenectady have realized the importance of this and have had a diamond drill at work on their mica properties for the past year. They are using a drill manufactured by the American Diamond Drill Company of New York, having a capacity of a thousand feet. The diameter of the core taken out is one and three-eighths inches. The large size of the bit is necessary since the mica will not core when using a small-sized bit, as seven-eighths inches. This diamond drilling which I have cited is the first that has been done in search of mica and the usual results that attend the exploration for other minerals with the diamond drill have been obtained.

In India the methods of mining, as has been mentioned, are very crude. The mines are in the interior and very inaccessible. The mine known as the "Abruker mine" produces the finest mica that has ever been mined. This mine has been sunk about two hundred feet following the pitch of the vein and all the mica and refuse has been raised and carried away by the natives. No machinery of any kind is used here. The refuse and the mica are placed in baskets, which hold about ten pounds and are passed up from hand to hand by the women who stand in a line on the ladder. When the top is reached the baskets are dumped and sent down

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the ladders in the same way, but by another line of women. Water is taken out by jugs.

In the United States and Canada the methods of mining are of course more modern, but even at the present time there are but few of the mines past the development stages. The methods of mining the pegmatites of the United States and the mica vein of Ontario and Quebec being very similar, I shall describe them together.

Mica mining differs from metal mining in many respects. On account of the mica plates being so easily broken and their value decreased it is necessary that great care should be taken in placing holes for blasting, and that the distance through which the material has to fall after blasting should be small. The method of open quarrying is quite frequently employed. This method is very objectionable in a country with a climate like that of Ontario and Quebec. In winter the sides of the open cut become coated with ice, rendering it extremely dangerous for any work to be carried on below. Underhand stoping has been employed in some of the mica mines in Canada but there are some objections to it. The stope has to be long and flat or the mica will be injured in blasting, due to the distance it will have to fall. When the stope is so flat there is considerable shovelling to be done to get the material down to the bottom of the stope where it can be loaded into a car or skip. Another objection to this method of stoping is that all the rock and gangue material has to be hoisted to the surface.

The method of overhand stoping has not to my knowledge been employed in the mining of mica either in the United States or in Canada. This method is illustrated in the accompanying sketch (diagram 4) and has the advantage that a clean and dry working face is always before the miner, on which the indications of a crystal are readily seen and the mica removed without damage. It has also the advantage that the mica can be separated from the gangue material in the mine, and this gangue and rock left in the mine as shown in the diagram. The mica is taken out by means of the chute as illustrated. When the vein or dyke is

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Section illustrating Overhand Method of stoping in Mica Mining
Scale 1 inch - 20 Feet
Diagram No 4

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found outcropping on a hill as it frequently does, the method of mining that would be best to adopt would be to drive a drift into the hillside following the dyke. From this a raise would be made to the surface for ventilation. The drift will be used for tramming out the mica; refuse and unwatering will be accomplished by gravity. The overhand method of stoping will be the best to be used as less mica will be destroyed.

We have in Ontario taken the initiative in mica mining. The Lacey mine, owned by the General Electric Company, is worked with the use of all modern machinery. The company has recently installed a six-drill compression plant. Power drills are used in all their mines. Other companies controlling mica mines are beginning to adopt the power drill.

The mica after being separated from the gangue material in the mine is hoisted to the surface and dumped into bins. From the bin it is taken and first rough cobbed, that is the broken or worthless mica is thrown away and the plates split down to at least one-quarter of an inch in thickness. In some mines the worthless mica is thrown away while rough cobbing runs as high as 60 per cent. of the run of the mine. This rough cobbed mica is then cleaned, which causes a further loss of 50 to 55 per cent. of the rough cobbed. After being graded, that is the one by three, two by three, etc., separated, it goes to the knives, where it is cut into the required shape and sizes and then thin split.

The best results that have been obtained in cleaned mica from the run of mine mica in any of the mines is about 50 per cent. This is very seldom obtained as the average amount of cleaned mica is from ten to twenty per cent. of the run of the mine.

Uses of Mica.

No other material has been discovered which can combine all the peculiar characteristics of the micas and consequently they have a wide field of usefulness. Mica is the "isinglass" of earlier times, when it was used for windows and lanterns, but this use has chiefly given way to glass, although mica chimneys for oil and gas lamps are becoming very general, especially in foreign

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countries. They are especially useful for this purpose in places where there are sudden changes of temperature; also used for street lamps and the lamps of tram cars. The slight tinge of color to the mica reduces the effective luminosity of the flame, but this is slight.

Owing to its capability of withstanding fairly high temperature it is used for windows in stoves and peepholes in furnaces, where it enables the operator to watch the process without suffering from the intense heat. The elastic character of the mineral is destroyed by the high temperature, so that it is then useless for any purpose to which ordinary mica is adapted. In India mica is used largely for ornamental purposes.

The greatest demand for the mica brought on the market at the present time is for electrical purposes. It is used for insulating armature slots, armature magnets, commutator cores, transformers, etc. Owing to its elasticity, even thickness and high insulating properties, mica surpasses all the artificial material prepared from either animal or vegetable substances. Different from these artificial substances, mica is incombustible and its insulating qualities are unaffected by time. It is especially necessary for electrical work that the mica should be free from cracks, flaws, or specks, since these cause imperfect insulation. These specks or inclusions as they are called, render some mica practically worthless. The inclusions are chiefly oxide of iron as hematite and magnetite or cubes of pyrites. Needles of rutile and tourmaline are also of common occurrence. The mica strips placed between commutator segments must be of soft quality, in order that they may wear down evenly with the copper. For this particular work soft homogenous amber mica is chosen and when split up into thin sheets (one thirty-second of an inch thick) it will wear down at the same rate as the hard drawn copper segments. If the mica is too hard the brushes wear the copper down quicker than the mica and if the mica is too soft it powders away and the commutator segments stand up above the pieces of mica between them. Both of these conditions cause "sparking." For large commutators the mica segments are built up of thin small strips arranged so as to break joints and make the required thickness.

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Micanite is now in regular use in electrical work. This is really an artificial insulator. It is made up of very thin sheets of the smaller grades of mica, being built up into large sheets by the aid of a cement, as shellac. An idea is prevalent that the mica used for the manufacture of this micanite is simply scrap mica. This is a mistaken idea, as the mica used for this is the small sizes, 1 x 2, 2 x 3, etc., and of a good grade. By means of this building up process we are able to use the small mica, 1 x 3 grade, etc. Were it not for this fact there would be no market for the 1 x 3 mica. The 1 x 3 grade and also the larger sizes, 2 x 3 and 2 x 4, are split down into thin layers and then built up into plates of any thickness required. The plates are usually made 18" x 36" and 36" square. Some of these plates are flexible and some are not. This depends on the use that is to be made of them. After the mica has been built up into these plates by means of a shellac it is put into steam presses and baked and steamed at the same time. All the properties of the shellac except the cementing quality are supposed to be eliminated in this process so that the insulating qualities of the plate are not reduced or lowered. After being baked and pressed the plates are milled for the purpose of making them smooth and even. They are then sawn into segments. If it is required to make rings, etc., out of this plate, they are made by steaming the micanite to the shape required. There is no place in Canada where micanite is made except that the Canadian General Electric Company build up some for their own use.

Other important uses of the mica are:

1. Manufacture of boiler covering from the waste products.

2. Manufacture of mica flour by grinding the mica waste, which was formerly of no commercial value. The mica flour is used for wall papers and decorative purposes; mixed with oil it is employed as a lubricant and serves as an absorbent of nitroglycerine in the manufacture of an explosive called mica powder. The ground mica is also used for tempering steel.

Canada at the present time leads the United States in the production of mica. British Columbia has as yet not been of sufficient importance as a producer of mica to be considered, but

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as its geological formations in some districts are suitable for the occurrence of mica we may expect that in the next few years British Columbia will become a rival of India in the production of muscovite.

The occurrences of mica, especially in Ontario and Quebec, is a question on which there has been considerable difference of opinion, and of course this paper can make no pretence to give an exhaustive treatment of the subject, but it is hoped that what has been said may form as a basis for a fuller discussion.

I need only say in closing that I wish to acknowledge my indebtedness to the professors in the departments of geology and mining of Queen's University for the kind assistance they have given me in the preparation of this paper.

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NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MILLER—The Province of Quebec is well known as a great producer of mica, and I would ask Mr. Obalski to say a few words on this paper.

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MR. OBALSKI—I listened with much interest to the paper and Mr. Corkill has covered the ground so thoroughly that there is nothing to add. In Quebec, as in Ontario, we have the amber mica and also the white mica. In the Saguenay district we find a large territory containing white mica which is not yet developed. Another variety of mica found in our province is the Lepidolite, found in the Leduc mine. Mr. Corkill referred to what he called the fissure-veins containing amber mica, and that shows that he is a very close observer. In our province we have the Vanassour mine in Hull township, which looks like a fissure vein or series of veins. Another use of white mica I might mention is for making masks for the use of automobile riders. They cannot put glass in these masks and so they substitute white mica, and a good market may be found for it in that direction.

PROF. MILLER—As to one of the points to which Mr. Obalski has referred, I understand that the white mica is mixed to some extent with phlogopite in the manufacture of micanite.

MR. FRALECK—I believe with Mr. Corkill, that genetically our phlogopite deposits are veins, although many physical aspects are very dissimilar. A length of fifty feet or over is very exceptional and in depth they are treacherous and uncertain. The dip varies from angle to angle and is sometimes reversed. Usually the vein matter repeatedly alternates from extreme leanness to extreme richness in mica. For these reasons the mining methods employed must be of the simplest description. However applicable the criticism in the paper may be to the pegmatite deposits of muscovite, it does not apply to the phlogopite deposits of Eastern Ontario and Quebec.

PROF. MILLER—I believe Mr. Llewellyn Morrison has had some experience with muscovite.

MR. LLEWELLYN MORRISON—I have had some experience with mica and have examined many deposits from North Carolina to Northern Ontario. In Methuen township, Peterborough county, Ontario, there is a very promising property partially opened that is very interesting. A range of syenite hills contains many intersecting veins and occurrences of nephilite in which, at or

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near the surface, many books or crystals of white mica occur. The plates have been taken out up to 3" x 10", but averaging say 3 x 4. The mica is a superior muscovite and quite equal to the finest India mica. At a depth of 10 to 20 feet, crystals or bundles of crystals of biotite begin to be associated, and both the white and the black mica have crystals of very pure corundum, up to half an inch diameter, peppered through the mica, rendering the white entirely unfitted for plate purposes. At 40 feet in depth one of these nephilite veins was practically a solid mass of corundum, muscovite and biotite, the two classes of mica mixed and jumbled together without any apparent order or system, about 40 inches wide. A rough analysis gave 62 per cent. corundum, 28 per cent. mica and the balance rock matter and rubble.

In a range of blue-gneiss lying parallel with the syenite and said by Prof. Miller to be a synclinal fold, as the syenite appears again about a half mile distant and parallel. There are many dykes of syenite-pegmatite and spars cutting the blue gneiss and considerable mining for mica has been done in these, especially on the north side, by the late George Bennett and others.

The muscovite is of a similar quality to that found in the syenite, the shade being a wine color, very similar to the pink of the India mica. The India mica is considered the finest in texture and transparency in the world, and I consider this Methuen mica quite equal to it in every essential particular. The biotite crystals are also associated with the muscovite crystals in the dyke and some of them are very large, one appearing to have been about 30 inches in diameter and over 6 feet long. The biotite, when scaled very thin, is a pea-green and produces a superior class of ground mica. That, I fancy, is the only use to which it can be put. I believe it has all the inherent qualities of the white mica except transparency and cleavage, and will yet prove to be useful for many industrial purposes. The discovery of corundum in some of these spar bodies, associated with the mica, principally as a core of the mica crystals, apparently put a stop to the mica mining. The corundum crystals being very pure oxide of alumina with a massive feathering of mica sometimes of the one kind and sometimes of the other, with an occasional

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book of plate mica, make a very interesting geological and mineralogical study, that I believe is as yet but very imperfectly understood.

The blue gneiss of the Methuen area I found to be different in texture and appearance under the glass to other occurrences over Ontario, which I believe to be due to its association with the syenite, which is rich in alumina, and I have been steadily on the watch, in field work, for the last four years to see if I could find a similar kind, but was unable to do so until October, 1903, when I came on a considerable area of a similar character, and proved my conclusions by finding that it carried pegmatite and spar dykes similar to that in Methuen, and still further by finding an exactly similar character of muscovite in the spar dykes. This area of 2,000 acres or thereabouts is entirely outside of ordinary localities mapped for minerals and is interesting in many ways. The mica has a dark stain or shade, but is beautifully transparent when cleaved to the proper thickness for use as plate mica. I hope during next season to have the opportunity of examining the locality more carefully, and will then report to Professor Miller, with samples.

My observations lead me to believe that areas of this kind, syenite, gneisses, pegmatites, spars, etc., carrying mica and corundum, will yet be found over a stretch of country from Methuen to Lake Nipissing, many of them large and valuable enough for economic mining.

MR. FRALECK—Under these conditions, in my opinion, there are only a few exceptional instances where the hand work, underhand stoping, derrick hoist, etc., can justifiably be superseded by machinery. One might better continue to "ground-hog" than to decorate the landscape with any more scrap heaps which are already too numerous in our country.

DR. ADAMS—I am much interested in the statement of Mr. Morrison with regard to the association of muscovite and biotite in Methuen. When making the geological survey of that district for the Dominion Government I noted this somewhat unusual association of the two micas and have referred to it in the report

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now in press. It seems to be connected with the fact that the pegmatite veins here are not of the ordinary type. They contain no quartz but are syenite pegmatites, being composed of feldspar and the two micas in question. These black micas of this district are turning out to be quite remarkable in character, being very rich in ferrous oxide and peculiar in many other ways. The lithia mica which has been discovered and which has been referred to in the paper is of considerable interest from an economic as well as from a scientific standpoint, because we often find it associated with many rather rare minerals, among which is the tin ore. I believe that lithia mica has already been found in Canada in but two or three places.

MR. OBALSKI—The mica from the Leduc mine was considered to be muscovite for some time, but analysis has shown that it is lepidolite, and tourmaline of different colors are found in association with it. The mine is situated in the 7th range of Wakefield, ten or twelve miles from Ottawa.

PROF. MILLER—I was very much interested in hearing Mr. Corkill's description of the method of pumping water out of the India mica mines. It seems to be similar to the methods used by the Romans in their mining operations, but of course they had numbers of slaves to do the work by hand. The origin of the name muscovite is of some interest at present, as I believe it originated in Russia on account of their using white mica for their windows in place of glass.

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Journal of the Canadian Mining Institute, Vol. VII.

Student's paper, presented for Prize Competition.

THE CHLORINATION OF GOLD ORE OF THE NORTH BROOKFIELD MINE, NOVA SCOTIA.

By H. L. Forbes, McGill University, Montreal, Que.

Toronto Meeting, March, 1904.

The ore milled at North Brookfield is obtained from a fissure vein running through the Cambrian series.

It consists in general of quartz, slate and quartzite, the proportions of each varying widely, the last two forming about 70 per cent. mispickel ($Fe\ A_3S$) and iron pyrite (FeS_2), each form about 0.5 per cent. of the ore. Galena (PbS) zinc blende (ZnS) and malachite ($CuOH_2$) CO_3 exist in small quantities varying with the richness of the ore.

The ore is treated in a twenty stamp mill, the milling process being the same as that carried out in most gold mills. I will not dwell upon it, outside of stating that they aim at producing a minimum of slime and at the same time recover a large portion of their gold in the stamp battery.

From the end of the mercury slates the pulp is conveyed by launders at right angles to the plates to the concentrator shed, and here is run on Wilfley concentrators, two in number. The shed also contains an Overstrom table (see Fig. 1), which is brought into service in an emergency.

The Wilfleys, by frequent assays of their tailings, are kept working to a high degree of efficiency.

From the record of these assays the best results are seen to be obtained when the concentrators are working under the following conditions:—speed 150 revolutions per minute, an upward slope of 1 inch towards the head, wash water enough to give the sand a free motion on the table and to keep it from clogging. The water supply should be kept well regulated.

Several styles of concentrators have been tried on this ore,

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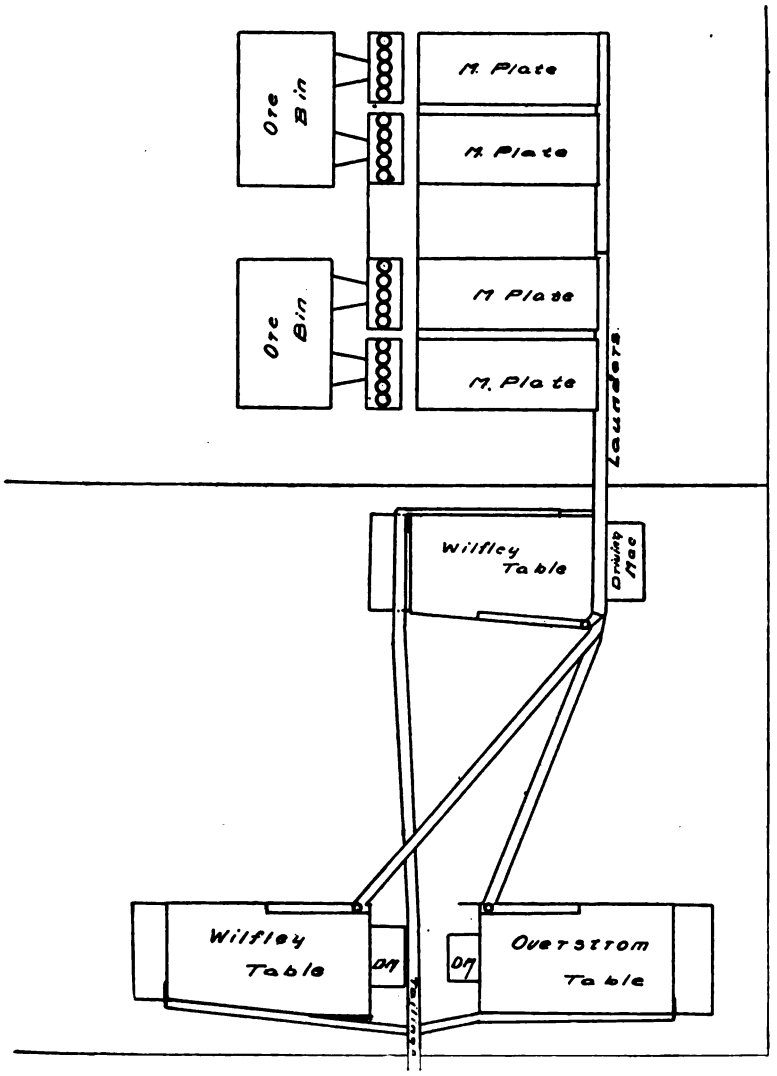

FIG. 1.—Plan of part of Mill and Concentrators.

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but the Wilfley has given the best satisfaction, in that it handles large quantities of pulp, produces clean concentrates and requires very little attention.

From several screen analyses that I have made on the concentrates from these tables, the average results were as follows:

10%	passed	through	20	mesh	and	remained	on	40 mesh.
13%	"	"	40	"	"	"	"	60
10%	"	"	60	"	"	"	"	80
27%	"	"	80	"	"	"	"	100
30%	"	"	100					

The concentrates contain approximately 30 per cent. of gangue, the remainder being sulphurets.

From the head of the table the concentrates are conveyed to a shed, where the excessive moisture is expelled from them by the heat from the exhaust steam pipes of the mill, which pass through them. The moisture here is brought down to from 3 per cent. to 7 per cent., depending on climatic conditions. From this shed the concentrates are conveyed by a car to the chlorination plant.

The chlorination plant was constructed after plans made by Mr. A. Theis, and the process carried out was originally introduced by him.

To put the concentrates into such a condition that the gold can be extracted as a chloride without using an extravagant amount of chlorine they must be roasted to drive off the sulphur and arsenic, which otherwise would use up the available chlorine, turning it into HCl.

The roasting is carried on in a housed reverbatory furnace, that part in direct contact with the heat being of firebrick. These furnaces have an unbroken hearth 39 feet long and 9 feet wide. A bridge wall of fire brick one foot high and one foot thick separates the hearth from the fire place proper, which is 9 feet long and 4 feet wide. Height from roof to hearth of the fireplace is 4 feet.

The other end of the hearth connects with the chimney by a flue tapering in 20 feet from 8 feet by 2½ feet to the chimney, which is 2½ feet by 2½ feet. Along the bottom of this passage are several openings into a dust chamber below, part of the fine

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dust carried off from the hearth by draught settles through these openings and is recovered in the dust chamber. Much of the remainder collects at the bottom of the chimney from which it is removed when the dust chamber is emptied.

The furnace is provided with working doors on both sides, these doors being 8 inches by 14 inches in the clear and 6 feet apart. The hearth is 3 feet 6 inches above the level of the floor of the building and the roof, which is arched, clears it by 24 inches in the centre and 14 inches at the sides.

The whole furnace is held firmly together by iron rods attached to brick stays made of light rails, and the rods are arranged with threaded ends and nuts to make allowance for the expansion and contraction.

A charge of 22 cwt. of the concentrates is dumped every 8 hours into the back part of the furnace, and when levelled off is about 4 inches deep. Two men on each 8-hour shift rapple the ore with iron hoes. Three charges are in the furnaces at the same time. The men divide their time to the different charges about as follows:—one-half to the third or that farthest from the five, one-third to the middle and the remaining one-sixth to the front or first charge. These men also attend to the fires. The fuel used is dry hardwood, this giving the necessary hot flame which extends over the first charge. Two cords of wood are required in twenty-four hours by each furnace.

The moisture is soon expelled and white fumes of SO_2 and $As_2\ O_3$ begin to rise. These increase until the flume of the burning sulphur and arsenic extend over the surface of the charge.

The working doors of this section of the furnace are then opened to allow sufficient air for the oxidation to take place, as not enough comes through the fire uncombined for this purpose. The concentrates at this stage require frequent rappling to keep them from lumping, which would deter the oxidation.

As the ore increases in temperature it swells, occupying more space. After the charge has been in the furnace 8 hours the flames have subsided. White fumes of sulphur and arsenic oxides still rise quite thickly, and the charge has reached nearly a dull

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red heat. It is then moved by means of an iron rail into the middle portion of the furnace, where it quickly takes on a dull red heat.

The ore while in the back portion of the furnace increases in its mobility. This mobility reaches its maximum after the charge is 4 hours in the middle of the furnace. The concentrates have then reached a red heat and are quite runny. On running the rappler over them the side of the ridge formed quickly runs back or will not "stand up." The brightening of the fresh exposed surfaces, which was first marked when first moved to the middle portion of the furnace, becomes less marked as time goes on, and the sand that is tossed by the hoe has an increasing quantity "falling dark." After 7 hours in the second portion of the furnace the charge is moved to the front or hottest part of the hearth. From this on no fumes can be detected rising from the material. After the concentrates have been a short time in the front portion they take on a bright red heat; the sulphur content in them is about 2 per cent.

The faint bright streaks which follow the rapple when the charge is moved to the front soon disappear, and the tossed ore "falls dark." The mobility which started to decrease while in the second portion of the furnace has nearly disappeared. The sides of the ridges formed by the hoe going through the ore will retain their face or "stand up." This rigidity was the last indication that I was able to observe regarding the progress of the roast from appearances in the furnace. The time when this stage is reached is taken for the success of the roast, ore drawn then having a slightly darker reddish brown than that of the finished roasted ore. Sulphur determinations on this average about 15 per cent.

The charge is allowed to remain in the front of the furnace 7 hours. Should the above stated changes take place within reasonable limits of the time stated, the charge is then withdrawn. Sulphur determinations on the finished ore run 1 per cent. or under. Should these changes not occur as mentioned, the charge is kept in the furnace until it is thought to be roasted sufficiently; any doubtful material has a sulphur analysis made on it. Any running over 1 per cent. are introduced in small quantities into the

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middle of the furnace with a succeeding charge, or kept until the end of a run and then passed through the furnace separately.

The charge is withdrawn from the furnace by means of a door in the hearth near the fire, which is closed when not in use. The charge falls through the door into a wheelbarrow run in a passage under the hearth. It is then wheeled to another part of the furnace room and spread on a brick floor to cool.

The need of a short and accurate scheme for sulphur determination is greatly felt, as a chemical analysis requires some hours.

A method used to obtain quickly an approximate idea is based upon the greater specific gravity of the unroasted to the roasted ore, and the difference in color of the same. A sample of about ¼ lb. is panned in a gold pan and scoured frequently by means of a stick, which tends to separate the roasted from the unroasted in the grains. By the quantity of black or unroasted sand remaining in the bottom of the pan an estimate of the amount of sulphur is obtained. This method, with practice, takes but a few minutes and the information gained is frequently all that is required.

From the cooling floor the roasted ore is conveyed by an endless belt and bucket elevator to the upper floor, the fifth of the chlorination building, and there dumped into a car. Ton charges are emptied from the car through a hopper into a chlorination barrel on the floor below. These barrels, four in number, are made of iron lined on the inside with ¼-inch lead, to resist the action of the chemicals used in chlorinating. These barrels are 5 feet long and 25 feet in diameter. They also contain a manhole one foot in diameter for charging and emptying the barrel. A stop-cock is also attached to each barrel by which the presence of free chloride can be determined.

In charging the barrel water is first run in until it is about half full, this being enough to make the charge an easy flowing pulp. The ore is then admitted. The barrels are designed to hold a one-ton charge. The ore is followed by the acid (H_2 SO_4) and then everything is got in readiness to quickly seal the barrel when the bleaching powder is added, to thus prevent any chlorine escaping. Perfect sealing is obtained by wedging the cover of

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the manhole against a rubber gasket. The belt is then run on to the fixed pulley, and the barrel, which turns on oiled runners, makes about 14 revolutions per minute.

The quantity of chloride of lime Ca $(OCl)_2$ and sulphuric acid (H_2SO_4) is: 48 lbs. of acid and 13 lbs. of bleaching powder to the ton of ore. The relatively large quantity of acid to bleaching powder is necessary on account of the acid re-acting with the ore. The amount of Ca $(Ocl)_2$ varies with the available chlorine or quality of the bleaching powder used.

The chemical action which takes place in the barrel is complicated; but the important resulting reaction may be expressed simply as follows:

$$CaCl_2 + Ca(OCl)_2 + 2\ H_2SO_4 = 2\ Ca\ SO_4 + 2\ H_2O + CL_2$$
$$2\ Au + 3\ Cl_2 = 2\ Au\ Cl_3.$$

Should any sulphurets be present they are oxidized by the Cl breaking up the water into its two elements. The H combine with the Cl forming hydrochloric acid (HCl), and the O oxidizes the sulphides forming sulphates. Reaction is as follows:

$$4\ H_2O + 4\ Cl_2 + XS = 8\ HCl + XSO_4.$$

where X is the metal of the sulphide.

When the barrel is first started the pressure due to the gas liberated is quite strong, but it gradually diminishes as time goes on; the Cl being used up. After the barrel has run for 6 hours it is then tested for free Cl by the stop-cock in the side of the barrel. Its pressure is determined by its characteristic odor, or if present in small quantities by holding an ammonia bottle to the stop-cock. The Cl combined with the ammonia gas forming white fumes of NH_4 Cl.

$$2\ (NH_4) + Cl_2 = 2\ NH_4\ Cl.$$

If no Cl is detected an addition of Ca $(OCl)_2$, $CaCl_2$ and H_2SO_4 is added to the barrel and run for two hours more. If chlorine is present the charge is "turned down." It is discharged into a pivoted spout which directs the charge into one of four filtering beds or vats, each 9 feet long, 6 feet wide and 14 inches deep, made of wood and lined in the inside with ¼-inch lead.

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On top of the lead is the filter. The filters are made by closely covering the bottom with perforated clay tiles ridged on the bottom. These are covered with four layers of crushed rock carefully sized—the bottom layer being 1½ inches in diameter; the next 1 inch; the next ½ an inch, and the top ¼ of an inch. Each layer is 1½ inches thick. On top of the sand is a layer of gummy sack. Strips of wood 6 inches apart run across the gummy sack and tend to keep the bed uniform, and also protect it when cleaning off the charge.

Before "turning down" or running in the charge from the barrel, a stopper is placed in the spigot and water is added until it stands 3 inches above the gummy sack. This water acts as a cushion protecting the bed from the contact of the discharged ore. The water also facilitates the washing.

The charge is allowed to stand on the bed about 20 minutes before the spigot is opened and filtering begins. Wash water discharged against a wooden float keeps the ore covered with water until all traces of gold disappear from the escaping liquor.

The test for gold is made by adding some $FeSO_4$ to a little of liquid in a beaker, the gold if present is thrown down in a dark blue precipitate. The reaction is as follows:

$$2\ Au\ Cl_3 + 6\ Fe\ SO_4 = 2\ Fe_2\ (SO_4)_3 + Fe_2\ Cl_6 + 2\ Au.$$

The solution after leaving the filter beds is conveyed by lead pipes to large settling tanks on the floor below. This floor also carries the $FeSO_4$ generating tank. The $FeSO_4$ is made by adding $H_2\ SO_4$ to scrap wrought iron.

In the settling tanks any escaping sand from the vats settles at the bottom. From these tanks the solution is led by pipes into the precipitation tanks on the first floor of the building. The precipitate tanks are constructed of cypress and coated both on the inside and outside with asphaltum varnish. The diameter of the tank at the top is 7.5 feet and 8 feet at the bottom. The height of the tank is 3.5 feet.

Each tank has three spigots for running off the solution, one-half way up the side, another 3 inches from the bottom and the third in the bottom.

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Precipitation is made with ferrous sulphate ($FeSO_4$) a solution of which is run with the auriferous solution and turned off when all the gold is precipitated. This is determined by the color and smell of the liquor. The color is a definite shade of purple and no odor of chlorine can be detected. The solution smells "sweet." The reaction is greatly accelerated by stirring. After standing two hours the solution is again stirred and the precipitate is then allowed to settle. The reaction taking place in the tank is similar to that which takes place in the test for gold as stated above.

After standing at least 48 hours after precipitation the solution is syphoned off; with care the liquid can be syphoned within a few inches, generally 6 inches, from the bottom. The syphoned liquid passes through sawdust before it is lost. The sawdust takes up, at least partially, any escaping gold that may be carried away in suspension, and thus by burning the sawdust and chlorinating the ashes, the gold can be recovered.

After a month's time a "clean up" is made. The solutions in the precipitating tanks are syphoned off as low as advisable and the remaining solution is put into one tank. $H_2 SO_4$ is added in small quantities, generally 10 lbs. at a time, until most of the impurities which collect at the bottom of the tank are in solution. The chief impurity is Calcium sulphate ($CaSO_4$), which being slightly soluble in acid solutions and more so in chlorine water, is carried through the filter and passes in solution to the precipitation tanks, where it is precipitated by the addition of $FeSO_4$. The acid ($H_2 SO_4$) causes it to go into solution again and thus leaves the precipitated gold comparatively free and in a condition to settle.

After settling the solution is syphoned off and run into a separate tank in which it and the washings from the further treatment of the residue, are settled quite clear. The liquid is finally wasted and the settlings run back and treated with the other gold residue.

The gold precipitates and such of the solution as remains in the bottom of the precipitating tank are placed in a lead lined

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clean up tank; dimensions of which are 4 feet by 2 feet by 2 feet. Here more acid is added which dissolves more of the impurities. The solution is syphoned off as low as practical. This process is repeated until the gold is sufficiently pure to smelt.

The syphoned liquid is in each case put in the separate tanks mentioned above. The residue in the clean up tank is placed on filters, the liquid passes through, the gold remaining on the paper. After a few washings the filter paper or papers with the gold and the remaining impurities are dried and incinerated. The gold impurities and ash from the papers are mixed with the necessary fluxes: borax, glass, sodium carbonate, glass and nitre, and smelted in a graphite crucible. The gold obtained is of a high degree of purity.

It is possible that the yield of gold could be somewhat increased and the time of recovery equally shortened by using the modern process of precipitating with SO_2 and H_2S, and possibly by using a filter to recover the gold. The method would, however, involve considerable first cost for new apparatus, and the cost of its operation would probably exceed the advantage derived in a plant of this size, although it would undoubtedly be desirable in a large concern.

This paper has dealt exclusively with the concentrates of North Brookfield mine, but concentrates from various parts of Nova Scotia (after preliminary laboratory tests to determine the requisite proportions of chloride of lime and sulphuric acid) have been successfully tested, thus demonstrating the fact that the refractory ores of that province can be profitably treated by the chlorination process.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

DR. PORTER—In bringing the McGill students' papers before the meeting I wish to make an apology; not for the papers, but for my own misdeeds. For two or three years it has been the custom to have students' papers read by title merely, and when I was asked by the students of McGill in regard to the papers for

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this meeting I told them that the papers need not be provided with drawings, etc. Unfortunately two of the papers which I have brought up with me can only be understood by reference to a diagram or by the use of lantern slides. As soon as I learned that the papers were actually to be presented I telegraphed for the slides, but they are not here yet; they are necessary to explain some portions of the papers.

PROF. MICKLE—I did not notice anywhere in the paper that the value of the concentrates was mentioned.

DR. PORTER—I think that information was deliberately withheld.

PROF. MICKLE—One would be very much surprised if they used that unless it was high grade.

DR. PORTER—That question brings up a point that is very frequently involved in the presentation of students' papers. For example, I have a paper on the list which will have to be withheld from publication owing to the inability to get permission of the manager of the property described. That permission has to be obtained to publish some of this information. While I do not know that to be the case in regard to Mr. Forbes' paper, yet it was quite probable that he was asked not to go into the question of yields and costs. Sometimes students are given opportunities to report on the works, on condition that they will suppress certain facts dealing with the financial side. That is unfortunate. because it takes away half the value of the paper. We can only get our students into certain works by undertaking to keep quiet about business matters.

MR. MORRISON—I see it is reported that the Mic-Mac mine in the Leipsigate camp of Nova Scotia are unable to obtain more than 75 per cent. of their gold values by amalgamation, leaving about $3.80 in the tailings or concentrates, but I do not think they concentrate, but leach the whole of the tailings in cyanide. obtaining $2.83 per ton net, or 75 per cent. of the gold in the tailings, at a cost for cyaniding of $1.05 per ton. At the Brookfield mines concentration and chlorination yield about a similar result.

PROF. MICKLE—I would be prepared to bet that it is low. There is no secret about these concentrates, and if they were high grade I believe the company would like to have it known.

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Journal of the Canadian Mining Institute, Vol. VII.

Student's paper, presented for the Prize Competition.

A FEW FEATURES OF MINING IN THE REGENT GROUP OF MINES, NEGAUNEE, MICH.

By M. B. Atkinson, McGill University, Montreal, Que.

Toronto Meeting, March, 1904.

The Queen mine, or as it is officially termed, the Regent group of mines, is situated about a mile and a half to the southeast of the city of Negaunee in the Marquette iron region of Michigan.

This mine has six shafts, the Buffalo, East Buffalo, Old Queen, New Queen, Prince of Wales and the Blue, the last three only being in operation, the others having served their purposes.

The reasons the old shafts have been abandoned is that the ore body is in the shape of a lens, striking east and west, dipping north at an angle of about 38 degrees and pitching towards the west at an angle of about 45 degrees. The first shafts were sunk on the east end, and as the process of mining progressed the workings grew farther and farther from the shaft, consequently tramming the ore to the shaft and drifting in rock became more and more expensive, so it was found to be more economical to sink other shafts farther on.

Of the three shafts in operation, the Prince of Wales (or Prince) is vertical, and is used for lowering and hoisting men, ten men constituting a load, the "cage-tenders" or "landers" counting them off. The shaft is a two compartment one with inside measurement of 6 feet by 12 feet and is 440 feet deep. Two cages fitted with spring safety clutches run "balanced," the bottoms having two track rails, so that cars of ore may be run onto them, locked by means of bars and hoisted by 1¼-inch cables wound on two 10-foot drums operated by a 200 h.p. engine, the engine house being situated 150 feet from the shaft. A view of the shaft house is given on next page, fig. 1.

The "New Queen" shaft is an incline of about 60 degrees,

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FIG. 1.—View of Prince of Wales shaft house. A loaded car is just being taken off the cage onto the triller.

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400 feet deep, now used only for lowering timber, no engine being necessary, the loaded timber skip hoisting the empty by gravity, the drums being controlled by brakes.

The "Blue" shaft, from which the larger portion of the ore is hoisted, is a vertical two-compartment shaft, 600 feet deep, inside cross section 7 feet by 16 feet. Two skips holding six tons of ore each, running "balanced," are hoisted by 1¼-inch cables wound on 10-foot drums, operated by a 500 h.p. engine, at the rate of 25 feet per second. The cages of the Prince do not travel quite so fast when hoisting ore, and when hoisting men they run still slower, making the trip in 40 seconds.

At the foot of the Prince shaft a 12-foot drift running west for 300 feet through slate rock communicates with an inclined underground shaft, running the same way at a pitch of about 45 degrees and 160 feet deep. From the foot of this a drift runs on the left hand for 300 feet and branches, one branch leading to the Prince of Wales workings and the other to the Blue mine level, with which it connects by means of an inclined raise 85 feet deep.

The ore from the Prince mine is trammed along the drift leading to the Prince incline, and the cars are dumped into the skips capable of just holding one carful, varying from a ton and a half to two tons. The skips should be larger as the ore spills out a little on the way up. There are two skips running balanced operated by a small steam engine, and dumped into pockets at the top of the incline, from which the ore is re-loaded into cars, which bite onto an endless rope travelling at the rate of 5 feet per second and running to the Prince shaft. Here the cars are automatically disconnected from the cable, hoisted to the surface and dumped into pockets, and from these into railroad cars. While a full one is being hoisted an empty is lowered and returned, the same way, the drift having a double track.

The ore is soft and is worked by hand labor. The miners work in gangs of six divided into pairs. The ordinary hand steel is used with a seven pound long handle hammer. There are what might be called three methods of striking. First, and most effective, the "overhand stroke," used for holes above shoulder high and with a downward pitch. Second, the "underhand or swing-

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ing stroke," easy on the man, very powerful and useful with an expert miner. It is used on holes having a pitch upwards, and up to any height within reach. Third, the "counter-hole stroke," used for drilling "lifters." It is a very dangerous one for the man holding the drill, as he has to straddle it and therefore risks the chance of being hit in a vital part of his body should the "striker" happen to miss.

The speed of drilling in good ore is about a foot in 15 minutes, but jasper intrudes here and there, so the average is slower than this. The holes are drilled about 5 feet deep, and, where possible, with a downward pitch so that water may be used. A ring of braided rope, called the "mop" is placed around the drill to prevent the water splashing out on the miner. The man holding the drill turns it after every stroke so that the hole will be cut evenly, and on the manner on which this is done, quite a part of the speed in drilling depends. He also cleans out the hole from time to time with a scraper. In a two set room or stope, which is about 15 feet wide, anywhere from 9 to 15 holes are drilled, but usually very irregularly, as the centre is blasted out first, the miners making use of as many free surfaces as possible, so as to get the best results from the powder they use. The holes carry on an average one and a half sticks of No. 2 powder, which is 40 per cent. dynamite, the holes are about three or four feet apart. Previous to charging the holes, "sollar" or planking is laid down to receive the "muck" and some ore is thrown on the ends near the face to keep them from being thrown out. The "muck" is blasted down on these planks, from which it can be shovelled with greater ease and greater speed than without them. The use of "sollar" though expensive is advisable, as the men are then more contented and more work is accomplished.

The men work in two ten-hour shifts in twenty-four. Day shift from 7 a.m. to 6 p.m., and night shift from 7 p.m. to 7 a.m., the men being given a full hour on the surface from 12 to 1 in each shift. As it takes about twenty minutes to lower or hoist the crew, the actual time spent at the face is less than ten hours. The night shift work 11 hours, but do not work Saturday night, though the company pays them for six shifts in a week.

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but only if they work the full five shifts. Otherwise they only receive credit for the shifts they actually work, and no credit is given them for the extra hour. No work is allowed on Sunday. The night shift quit Saturday morning at seven and go to work Monday morning at seven, the shifts being changed every week.

When possible the blasting is done at "quitting time," both at noon and the end of the shift, in order to lessen the amount of time which is lost by waiting for the air to freshen after the blast. Compressed air is turned on before "firing" and left going to drive the gas out. On returning the miners' first duty is to sound and clean the roof. Large quantities of ore can nearly always be dislodged with only pick and bar, the miners using a single pointed pick.

The work of mining is set by contract whenever possible. Where sets are used, the price varies from $25 to $40, according to the nature of the ore. In scramming the contracts are set at so much a car, the price varying from 16 cents upwards. The miners fill the cars which are brought in and taken away by two trammers paid by the company (company account), at the rate of $1.85 per day. The cars hold from one and a half to two tons of ore. Each contract has a number, and where the trammers take away the loaded cars there is hung up a split ring holding a number of brass checks, with the number of the contract on them. The trammers take one of these brass checks with every full car and give it to the man overseeing the dumping at the shaft, who hangs it on a nail bearing that number. Thus, at any time during the day the output from the different contracts can be reckoned up; also the output of the mine is graded into three classes, viz.: Buffalo, or high grade ore (shaft signal one bell), Cameo, or low grade ore (two bells), and rock (five bells). The trammer is told by the miners, captain or shift boss, of the kind of "muck" he is tramming, and it is his duty to notify the "skip tender," who keeps tally and directs the dumping at the shaft. Thus the nature of the output can be reckoned up at any time during the day. The contracting miners must purchase from the company all mine supplies; picks, shovels, and axes are $1.25 each; the powder, which is the heaviest expense, is sold by weight at the rate of $14 a box,

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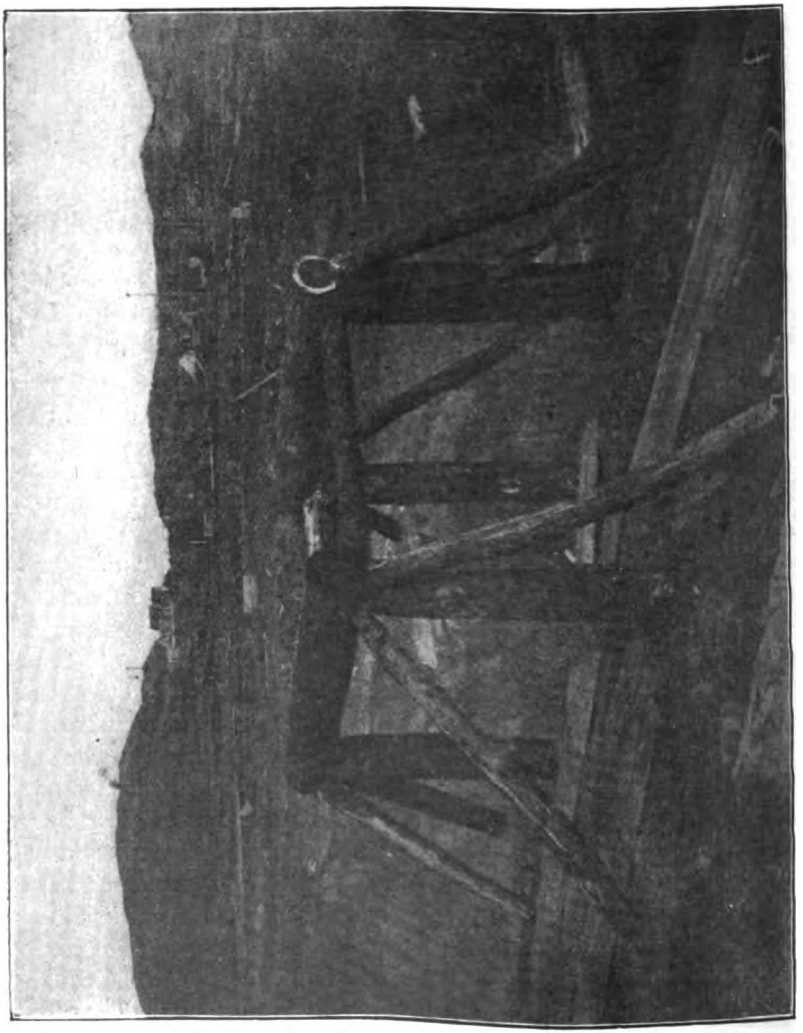

FIG. 2.—A very rough model of a square set—not at all good, but shows general principles.

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containing between 60 and 70 sticks; candles come at $5.25 per box, or about 2 cents apiece, etc. These men make between $2.20 and $2.50 per day. In case their rate should fall below $2.00 the company pays them $2.00 per day, which is the wage of a "company account" miner. If the men should quit and draw their pay they are only paid at the rate of $2.00, unless it is at the end of the month.

In general, the methods used for mining the ore are "square-setting" and "caving," which includes "scramming." Square-sets are only used when the hanging is a hard rock such as diorite. The ordinary California square-set is used (fig. 2), consisting of 7-foot ties and caps and 8-foot legs of cedar, 8-foot lagging of split spruce being used on top as a protection from loose rock overhead and also to hold up loosened ore. The work, on account of the irregularity of the ore, due to horses of jasper penetrating here and there, must necessarily be of an irregular character. The general line followed is to run in stopes or rooms at right angles to the main drift, these stopes being one, two, or three sets wide, usually three if possible. These are run in as far as the ore lies and worked up to the hanging, the timbering progressing upwards as well as forwards, one set being built on the one below. The top of each set is lagged over, so that the ore on being loosened above will not fall too far, as there would be danger of smashing out timbers, thus causing all the sets to tumble in. Another room is run in the same way farther down the drift, usually about 45 feet. Then cross-cut rooms are run every 45 feet, so that pillars of ore 45 feet or 5 sets square are left standing. The ore is not shovelled, the miners letting it down from set to set by moving the lagging so that the ore runs through. Chutes are built every second set, from which the ore is trammed. When the rooms are completely worked out the lagging is taken down and that which is useful used elsewhere.

When the level is worked out the pillars are removed in the following manner. Starting on those next to the hanging a drift one set wide is run into the centre, and then a raise of one set size is run right up to the hanging, the regular square set timbers being put in. Thus there is a square set in the centre of the

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pillar, and around the outside of the pillar are the legs, caps, and ties of the square sets of the surrounding rooms, so that the distance from this centre set to the ones on the outside is just two sets. The top of the pillar is taken out to the depth of one set, then caps of double the length of the ordinary ones are placed between the legs of the centre and outside sets, and the top heavily lagged. The pillar is then worked downwards, the long caps being put in every set as the work progresses downward, but only the top sets are lagged to protect the miners from any rock which may "wind" off from the hanging. The ore is worked down through the sets on all sides, thus making cheap handling, in fact this way of getting out the ore is the cheapest in the mine. When all the pillars are taken out and all work has ceased on the level, the tracks are taken up and the bottom of the level is completely lagged, except where it consists of rock, by simply laying lagging on the bottom, old lagging being used as far as possible. Holes are bored in every second leg in the bottom sets, sticks of powder with fuse and caps inserted, and the timbers blasted, thereby usually bringing down the roof, the whole mass of timbers and rock falling on the lagging.

Scramming is used to take the ore from under this on the level below. In scramming the work is laid out in areas of fifty foot squares. Every fifty feet a raise 4 feet by 9 feet is divided into two compartments, one for a chute and the other for a ladder, is run up with a pitch usually of about 77 degrees, in order to break the fall of the ore in the chute. The miners working in one "scram" are given a contract at so much a car, the price varying very much from 16 cents up. The raise is run up to the lagging on the level above, 85 feet usually intervening between levels. The miners start 9 feet down from the lagging and run in a drift 25 feet long from the raise, timbering up with caps and legs, braces or "sprags" being used to keep the legs apart, the so-called sets being about 7 feet wide and 4 feet long, the lagging laid down formerly resting on the caps and holding up the debris. The timbers are very much smaller in diameter than those of the ordinary sets, caps being about 8 inches or 10 inches and the legs 12 inches or 18 inches. The ore is shovelled into a wheelbarrow

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and dumped into the chute. When this drift is completed another is run in alongside of it, the bottom is lagged, then the legs are blasted out, and these two drifts cave in. The process is repeated until the slice of 9 feet deep is taken out, and the whole area of about 2,500 square feet is caved in. If the nature of the "back" warrants it, sometimes two drifts are run side by side before blasting down the timbers.

When the "slice" is completely taken out and the timbers blasted in the miners start in from the raise 9 feet below the floor of the previous slice, and working up to the lagging previously laid down proceed to take out the ore as before. In this way the work is carried on down to the level, the debris coming down as the ore is cleaned out.

Contrary to what would naturally be expected, this is a very safe method of mining and very few men are hurt, the reason being that the back is always near the miner and gives him warning when there is danger. When a drift is run and timbered up, as the work progresses the timbers first put up begin to crack, this is a good sign as it shows that the mass of debris above is settling slowly down on them. If the timbers do not show that they are bearing great weight then the debris above has become "hung up" and has formed an arch, which may break at any moment and come down with a crash. The miner seeing this sign must proceed to make it come down by blasting or leave the place alone. But on the contrary, when the mass above is bearing on the timbers the men are safe, as the mass of mingled rocks and timbers settles very slowly, an inch or so a day. Timbers of large size supporting this load will first bend, then crack, and lastly break, allowing loose dirt and rock to run through.

This method of "scramming" or "top-slicing" is used not only under a worked out level but also in new workings, where the hanging consists of sand, gravel or loose rock. In this case the miners bring down the surface with them, thus forming great pits above (fig. 3), which must be roped off for the protection of the public.

While a level is being worked, a new one below it is being opened up and developed. Usually a winze is sunk not very far

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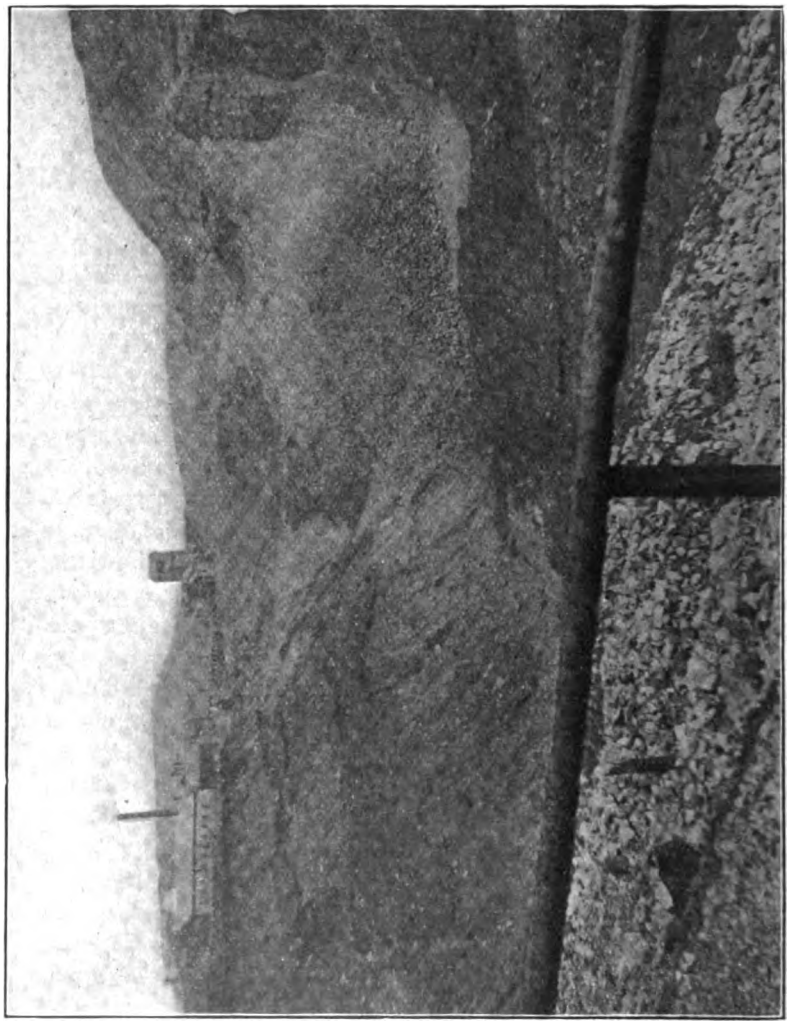

FIG. 3.—A pit caused by caving.

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from the shaft. In a case observed during my stay at the mine this winze was sunk about 300 feet northwest of the Blue shaft through slate rock with an incline towards the south of 77 degrees to the horizontal, for a depth of 85 feet. The dimensions of the winze were 12 feet by 7 feet, and it was divided into two compartments. One, not timbered, was used to hoist a half-ton bucket, which slid on two skids and was operated by a compressed air hoist. The other compartment was planked in and used for a ladder way, the ladders being alternately sectioned and manholed. At the foot of the winze a 12-foot drift was run east and west, two air drill machines (Rand No. 2) being employed, as hand labor would have been too slow, in rock. The machines were run by four men. Usually twenty-two holes were drilled in the face, the machines being used on an upright column with an adjustable arm. The four cut-holes in the centre were fired first, with an electric shot firer made by the Atlantic Dynamite Co. It has a capacity for firing eighteen holes and was of the well known pull up dynamo type. These centre holes carry three sticks of No. 1 powder (50 per cent. dynamite), special caps fitted with wire connections being used to set off the charge. The "muck" was shovelled into small cars and dumped into the bucket by two trammers. The rest of the holes, with the exception of the four "lifters," were next charged and fired, and after the dirt was cleaned up these latter were blasted. The holes were all drilled wet, the water for those having an upward pitch being pumped by a small pump, through a hose, from a sump at the foot of the winze, and fed by means of a long thin gas pipe into the hole. As soon as the men completed drilling in one face they would set up in the opposite face, and proceed with drilling there, stopping to fire holes in the first face as needed. As the place was very wet the holes had to be blown out with compressed air by means of a long bent pipe on the end of a hose. The usual charge was two and a half sticks of No. 1 powder, and for all except the four cut-holes the ordinary fulminate of mercury cap and fuse (one foot per minute) were used to fire the holes. The fuse were all cut the same length and lighted in the order of rotation required for blasting. The work was set by contract at

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so much per foot advance. In this case $12 per foot was paid, the men paying for their powder, fuse, caps and candles. A box of powder was used to a round of 5 feet, 5 candles to a man per day and six feet of fuse to a hole.

The drift was run in on the west side about 100 feet before ore was struck. A gang of hammer and drill men were then brought down from the upper level and put to work mining on the ore side. Square setts were started, those which were put in the drift taking an 8-foot cap, so as to give them room for a double track. The continuation of the drift after ore was reached was done by hand work and at the same time a drift was put in a short distance towards the north and from it a raise was worked up to the level above for ventilation. This was much needed as the air was very bad, notwithstanding that after every blast compressed air was turned on.

On the rock side the drift was run in 100 feet and then a cross-cut was started from it. The end of the cross-cut on the north side was sent in 15 feet so that another raise could be sent up for further ventilation and to lower timber through. The other end of the cross-cut was advanced towards the Blue shaft, under which it would come and connect with by raising. The main drift was to be advanced forward and connected with the New Queen shaft. A timber chute would then be built in this raise and timber lowered down from the "New Queen" level. The boundaries of the ore were to be found by means of drifts.

Pumps were scattered through the old as well as the new workings near the shafts as follows:

PRINCE OF WALES
3 pumps, 75 gallons per minute, capacity 200.

OLD QUEEN
3 pumps, pumping 250 gallons per minute, capacity 1,000.
1 large Worthington pump, 750 gallons per minute.

NEW QUEEN
1 pumping 20 gallons per minute, capacity 50 gallons.

BLUE
1 pumping 100 gallons per minute, capacity 500 gallons.
1 Prescott pump with a capacity of 1,000 gallons.

The Prescott pump had just been installed; it is a duplex triple expansion, surface condenser with air-pump. Steam at 125

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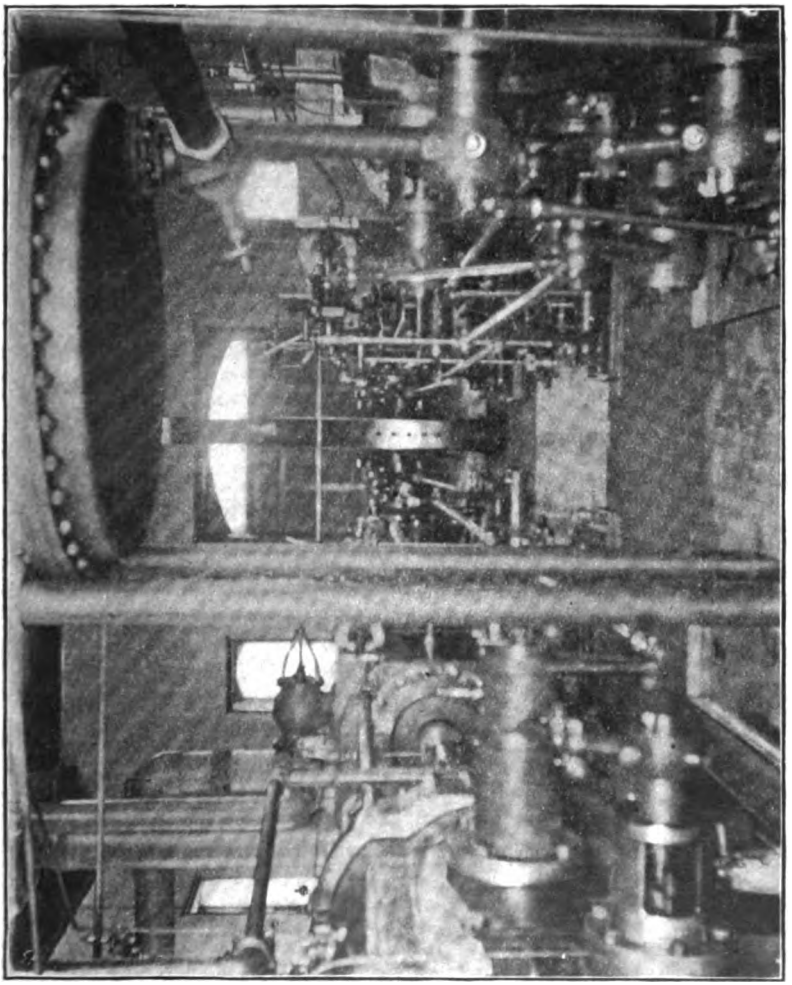

FIG. 4.—A typical air-compressor, duplex, triple expansion, Corliss valve, condensing engine. Air chambers in foreground.

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lbs. was used for this pump piped down from the boilers at the Blue shaft. The steam for the other pumps came from a large boiler at the Old Queen shaft. The large Prescott was installed for the purposes of relieving some of the other pumps and dispensing with the services of one man. Three pump men were employed on each shaft. The small pumps could be coupled to the compressed air pipes, the air being furnished by a 16 drill compressor on the surface at the Blue (fig. 4). In many cases the pumps were put in in pairs, one to act as a relief to the other in case of a break down. Two No. 10 Cameron pumps were being installed to act as relief pumps to the large Prescott pump at the Blue. The kind of pumps most favored by the management were the Knowles, Cameron, Prescott and Worthington.

The ore of the mine, like that of the whole district, occurs in what is called the Negaunee iron bearing formation. It consists of a hematite of medium hardness formed by the aqueous decomposition of the original cheoty carbonate of iron or siderite and the subsequent precipitation and deposition as $Fe_2 O_3$ on the impervious Siamo slate, forming the foot wall of large troughs caused by the folding of the strata. The deposits are pierced with numerous dikes of diorite and horses of jasper occur throughout the ore body.

Ores are divided into two groups, Bessemer and non-Bessemer, according to the amount of phosphorus present. Standard ore is as follows:

Iron	63.000%
Phosphorus	0.045%
Water	10.000%

If the phosphorus is over this amount the ore is non-Bessemer. Those near the standard can be mixed with an ore low in phosphorus, and used as a Bessemer ore. Very high phosphorus ores are used for special purposes such as foundry castings, stoves, etc., and form a class by themselves. Frequently the ore near the edges of the body, especially near the "paint rock," are high in phosphorus, while the main body may be Bessemer. Usually yellowish ores are high in phosphorus.

As already stated the ore of the Queen Mine is divided into

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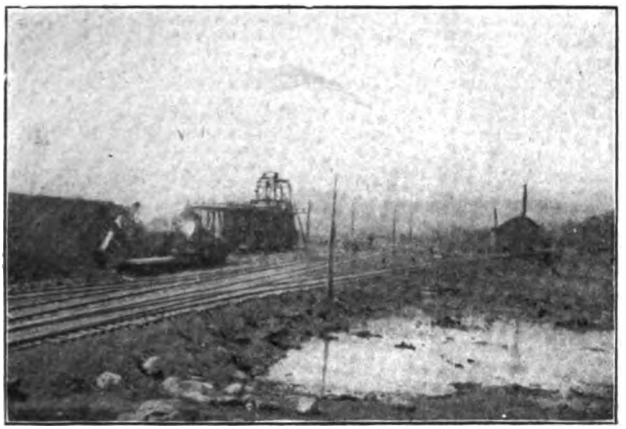

FIG. 5.—Steam shovel at work loading ore from stock pile.

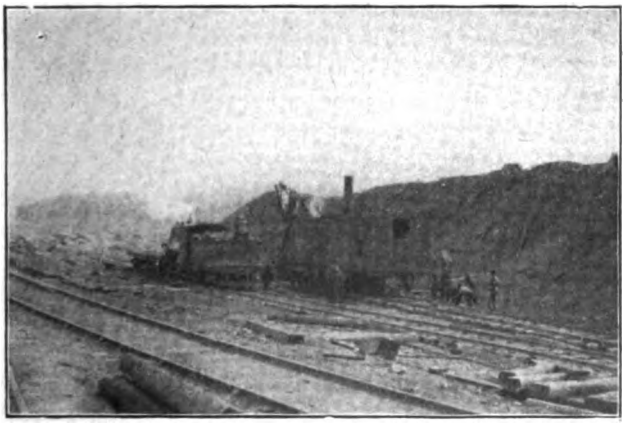

FIG. 6.—Another view of shovel.

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two classes called Buffalo and Cameo. For the season of 1902 the average analysis for 6 months was as follows:

	Iron.	Phosphorus.	Silica.
QUEEN MINE			
Buffalo	60.83	0.097	5.23
Cameo	58.03	0.094	6.77
BLUE MINE			
Buffalo	61.40	0.093	5.32
Cameo	58.45	0.095	7.13

In summer the ore is hoisted, dumped into pockets, and from them into railroad cars. The Blue "outputs" 450 tons per day and the Prince 300. In winter the ore is dumped onto stock piles and from these it is loaded into railroad cars by steam shovels during the summer (figs. 5 and 6).

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

PROF. MICKLE—I understand Mr. Atkinson to state that the miners receive 60 cents a car, does that mean a ton?

MR. DEYELL—A car will hold from 1½ to 2 tons.

PROF. MICKLE—What is that for?

MR. DEYELL—To mine it and put it in the car. It is put off into pockets at the shaft and they get 60 cents a car.

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Journal of the Canadian Mining Institute, Vol. VII.

Student's paper, presented for the Prize Competition.

THE PIONEER IRON MINE, ELY, MINN.

By E. J. Carlyle, McGill University, Montreal.

Toronto Meeting, March, 1904.

The Pioneer mine is situated in the town of Ely, Minnesota, about 100 miles due north of Duluth, and is connected with that lake port by the Duluth and Iron Range Railroad. The bulk of its shipments are, however, made from Two Harbors, farther north on Lake Superior.

The mine is one of many on the Vermilion range which are operated by the United States Steel & Iron Corporation and yields one of their best outputs. In fact its superintendent claims that for a mine hoisting through one shaft only the Pioneer has one of the world's largest outputs. In 1902 its tonnage was 679,766 tons. In July of this year 75,000 tons were hoisted and but for the present depression last year's output would probably have been greatly exceeded.

This satisfactory yield has been rendered possible by favorable natural conditions, and by efficient mining methods, and it will be the purpose of this paper not so much to completely describe the mine and plant, as to refer to those engineering features which were, to the writer at least, novel and different from any seen by him in Canada.

To gain an idea of the ore body some reference to the local geological conditions is necessary. The deposits are part of those included in the so-called Vermilion iron-bearing district of Minnesota, which extends from Vermilion lake N. 70 degrees E. to the Canadian boundary, a distance of 80 miles. Professor Van Hise of the United States Geological Survey has ascertained that the succession of formation in this district is as follows:

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Keweenawan	Great Gabbro
Unconformity.	
Upper Huronian.....	Upper Slate Formation.
	Gun Flint Formation (Iron Bearing).
Unconformity.	
Lower Huronian.....	Intrusives.
	Knife Slates.
	Lower Huronian Iron-bearing Formation.
	Ogishke Conglomerate.
Unconformity.	
Archean	Intrusive Granites.
	Soudan Formation.
	Ely Greenstone.

The Soudan formation embraces the deposits at Tower, Ely and on Hunter's Island in Canada. At Ely, two chains of hills begin at the town and extend north of east for about ten miles. The ore bodies rest upon the bottom and sides of a pitching trough between these series composed of an altered diorite which Mr. Van Hise has named the Ely greenstone. This rock forms an impervious basement, and the iron oxide, derived from original iron carbonates by the action of descending waters, has been deposited roughly speaking in a U-shaped mass along the sides and bottom of the trough.

The Pioneer mine itself has not as yet been sufficiently developed to show the form of its ore body, but the workings in the Chandler mine immediately adjacent have been extended so far that it has been possible to prepare both longitudinal and transverse sections of the deposits. These sections are therefore shown below (fig. 1). Before discussing them it should be explained that the Chandler Company attacked the deposit at its outcrop and followed the ore eastward and downward to the boundary of their claim, while the Pioneer is simply continuing the mining from that boundary. This fact, together with the geological conditions referred to, makes it reasonable to believe that a transverse section of the Pioneer deposit would be approximately the same as that of the Chandler ore body, of which it is merely a continuation.

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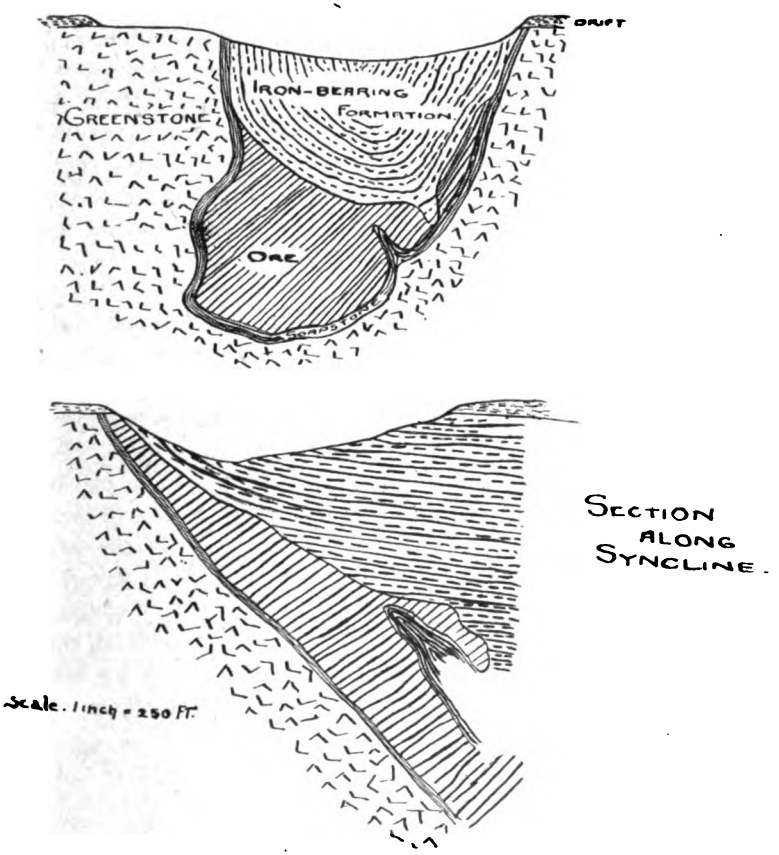
The iron-bearing, or more properly ore-bearing formation, so-called because the ore beneath has been derived from it, consists of jaspilite, which is locally called the jasper capping. It

SECTION ACROSS SYNCLINE

Fig. 1



rests directly upon the ore body, and along its sides is separated from the greenstone basement by a thin layer of soapstone, or "paint rock," which continues completely around the ore-body.

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The greenstone and the jasper are called locally the foot and hanging wall, though of course erroneously.

A glance at the longitudinal section shows that the ore body is increasing with the pitch. The inference is therefore that the Pioneer has a much larger mass of ore in store than did the Chandler, and this is believed to be the case.

The ore is hematite, varying from a hard, specular sort to a red, somewhat hydrated variety. Two grades are recognized in the Pioneer, differing noticeably in the proportion of three important constituents, namely the iron itself, the phosphorous and the silica. The better grade is called "Pilot grade," and carries 67.13 per cent. Fe., .029 per cent P., and 2.55 per cent. SiO_2, while the second or Pioneer grade has 63.95 per cent Fe., .036 per cent. P. and 5.85 per cent SiO_2. The Pilot grade is a tougher rock and breaks up less readily in the process of mining than the softer Pioneer grade of the ore, and as a result the two are fairly well separated by the grizzlies in the shaft house.

Emphasis must be laid upon the readiness with which the ore as a whole breaks up into small particles. At the furnaces this characteristic has been somewhat of a disadvantage; but in the mining itself it is of very great advantage, making possible the system of caving and milling which will presently be described.

Development.—To show the method whereby the ore body was approached a rough section is shown in fig. 2. It will be seen that the vertical shaft, A, was begun at the edge of the greenstone foot wall and levels established at intervals of about 100 feet. From each station it was necessary to drift through the greenstone and paint-rock to the ore body, as shown in sketch plan below, A. These drifts were made large enough for double track transportation, being in section about 10 by 20 feet. They

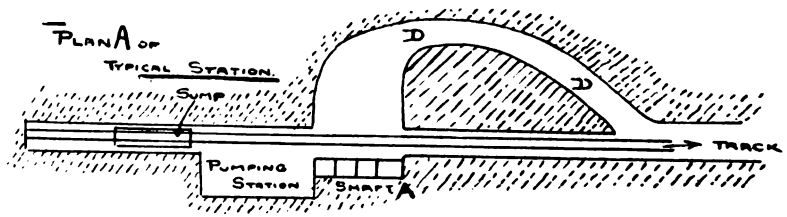

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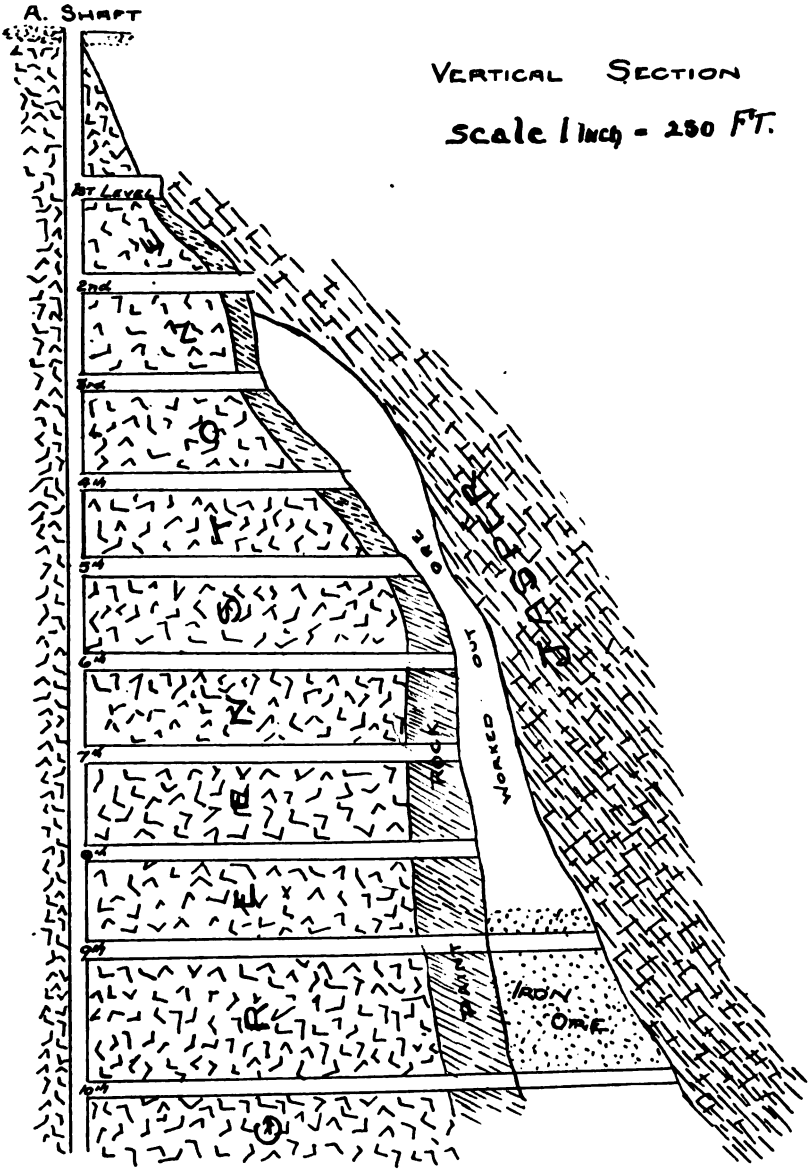
FIG 2.



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extend on past the shaft and pumping station far enough into the diorite to make room for a train of 18 cars, and the sump for each level is located in this train-way. From the back of each station an auxiliary drift, DD, has been driven for purposes explained in the paragraph on underground transportation.

By referring to the section shown in Fig. 2 it will be seen that the length of these rock drifts increased from 50 feet on the first level to 200 feet on the fourth, because of the slope of the foot wall. But from that point downward the foot wall has proved to be nearly perpendicular and on each of the lower levels about 275 feet of drifting has been necessary to reach the ore body.

To explain the procedure after the completion of these drifts, the tenth level and its sub-levels will be described and illustrated by Fig. 3, which is a plan of the tenth level.

On reaching the ore, workings were extended to the left and right. In the former case jasper was reached fairly soon and the most of the development was in the other direction. Two drifts, DD, were carried along the lateral confines of the ore body, which for some distance only reached a width of from 50 to 100 feet. And cross-cuts, CC, were driven at intervals of 60 feet, dividing the ground into the pillars, PP.

As the ore body widened out the number of drifts was increased and their direction was made parallel to the line, LL, which marks the boundary between the Pioneer and Chandler properties.

The cross-cuts between drifts were in all cases driven so as to meet the drifts at acute angles, as in the Fig. B. This made it subsequently possible to employ gentler curves on the track ways than if the pillars had been made rectangular.

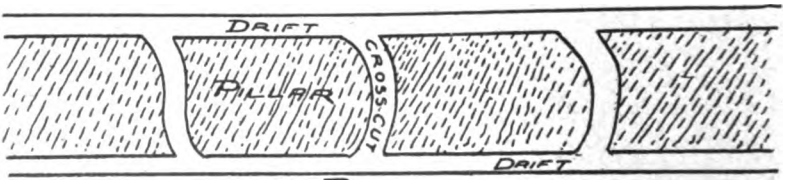

Fig. B

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At the time of the writer's visit, the development of this level had reached the stage in Fig. 3, and was practically complete. But the developments of the sub-levels had been going on also. As soon as the ore body was entered, raises were made at the points, KKK, and from them the development of the sub-levels begun, as shown in sketch C. Between each pair of main levels, three of these "subs" were extended, so that they were about 30 feet apart. As soon therefore as the raises were 30 feet above the main level, drifts were extended above and parallel to the corresponding drifts on the main level below. When the drift below had extended 15 or 20 feet further, a second raise was excavated to serve subsequently as a ladder way.

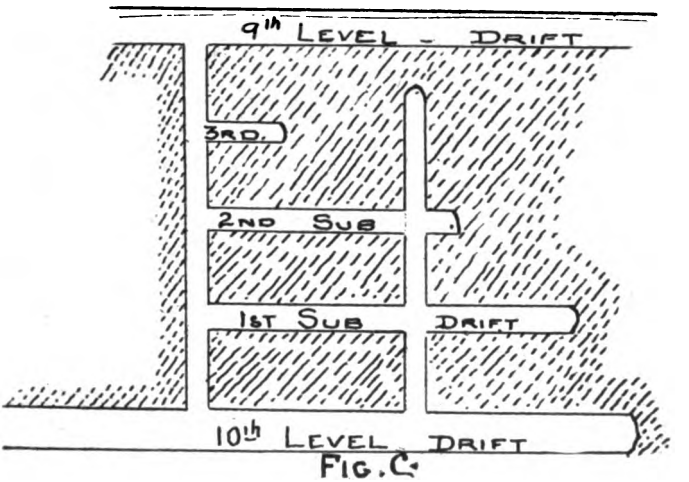

FIG. C.

As soon as the first subsequent drift was far enough in to make everything safe for the machine crew working in it, the first raise would be continued upward, and the second and third subs begun, till finally the raises would break through the main level above. As fast as the progress of the drifts permitted, cross-cuts were made on each sub above the cross-cuts below, so that finally each sub was a duplicate of the one beneath, and the pillars blocked out on the main level continued up through the three subs to the main level above. The work was proceeding in all four

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levels at the same time, that of a lower one being slightly in advance of that of the next higher up. Raises were begun in the drifts and cross-cuts as fast as 20-foot intervals were reached. As a result all the ore mined in the development of the subs could easily be moved in wheelbarrows to the raises (or chutes as they now became) and track laying was therefore unnecessary in the subs.

Manifestly the mere development of the main level and its three subs meant the production of large quantities of ore; but

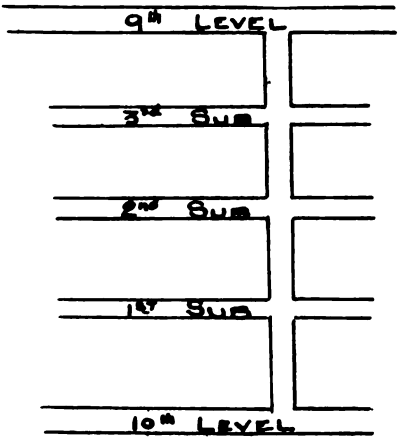

FIG. D

long before its completion the output was enormously increased by beginning the process of caving the pillars.

To understand this pillar-caving process fully, we must remember that as the ore body on the higher levels had been mined out the jasper capping kept crushing in. When the top sub was developed, there remained between it and this overlying jasper about 30 feet of unattacked ore, and also a great number of the main floor portions of the pillars on the level above. When a raise was completed it would therefore intersect five successive drifts, as shown in the sketch D. The caving process could now be commenced.

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Starting on the side of the ore body most remote from the shaft the 9th level pillars were caved down into the chutes.

Fig. E shows an ideal vertical section through two adjacent raises and the intermediate ground prior to caving. The bottom portion of the pillar on the 9th level is as yet intact, but all above it is mined out. Beginning at the points PP the miners would

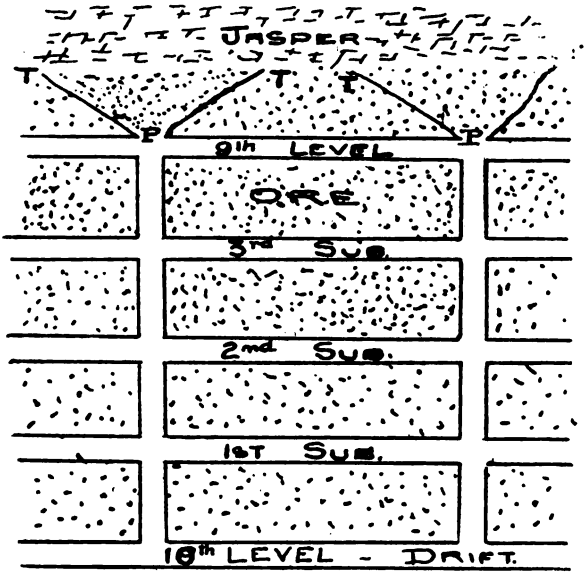

FIG. E.

blast down the ground above the lines PT and the ore would fall down the chutes to the track-way on the 10th level. It was in very few cases found necessary to do any drilling, either machine or hand, to successfully blast such ground. The crushing effect of the moving jasper above and the mining operations on the levels below, all tended to loosen and fissure the pillar, and in most cases the cave miner's only tools were a pick and a "pop-bar." The latter is a bar of ¾-inch steel sharply pointed at one end

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and flattened into a prier at the other (see Fig. F). Armed with this a man can easily enlarge small fissures, and in soft earthy ore dig out small shot holes 20 to 30 inches deep. In each cavity one or two sticks of 40 per cent. powder were tamped with clay. The discharge of several such shots would produce a

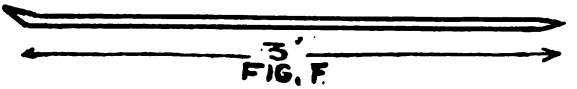

FIG. F

long run into chutes of well-broken ore. The caving is done from one side of the raise at a time and a dam, so to speak, of timber is arranged at the point where the cave discharges into the chute, and if at any time during the long run the appearance of jasper shows that the cave has reached the top of the pillar the flow is stopped and caving begun from another side of the chute.

A pillar is attacked from all sides in this manner and very soon is caved down until only a "hog back" remains, whose existence is due to the fact that the slope along AP (see Fig. G) is not sufficient to make the ground run. To win this, an inclined

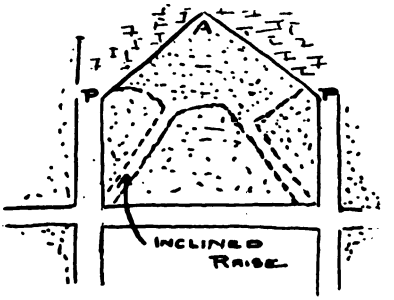

FIG. G.

raise, or several if necessary, is put up from the sub level below and the hog back is caved through this into vertical chutes. The next pillar is attacked in the same manner, and as soon as possible work is commenced on the same pillar one sub lower. Obviously caving cannot be begun on any sub until the ground above that sub is caved. A sketch is here given (Fig. H) showing how the caving in is proceeded with.

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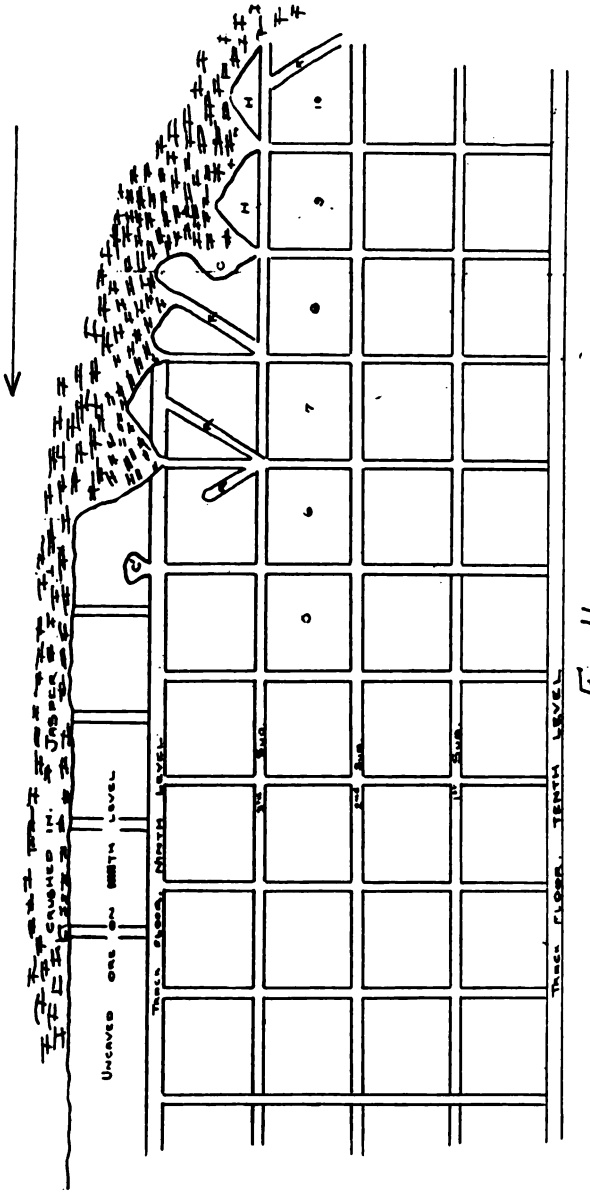

FIG. H

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This sketch, H, is purely an imaginary section, and very inadequately illustrates the caving process. The section is supposed to pass through two main floor drifts and the intervening sub drifts and raises, all in the same vertical plane. The line of retreat is along the arrow. Above the pillars 8, 9, 10, the ore on the 9th has been caved, and part of the pillars above the 3rd sub, so that the hog back SH remains. An inclined raise, R, is attacking one of these. The incline above No. 8 has tapped a hog back on the 9th and so on, C and C′ show where some caving has been done, C having been carried far enough and C′ just beginning.

It will be seen that the raises from the 10th do not coincide with those previously put up from the 9th. Such coincidence would not yield any especial advantage and would involve very difficult surveying.

However inadequate the sketch may be, it may, if considered in connection with Fig. 2, show how the remaining ore on the 9th is mined, and how the pillars on successive subs are caved in a series, so to speak, of large steps.

From this it will be seen that the method of mining is really a variety of stoping.

In many cases the slope of the foot-wall was such that considerable masses of ore on one sub, say at B in the Fig. I, would

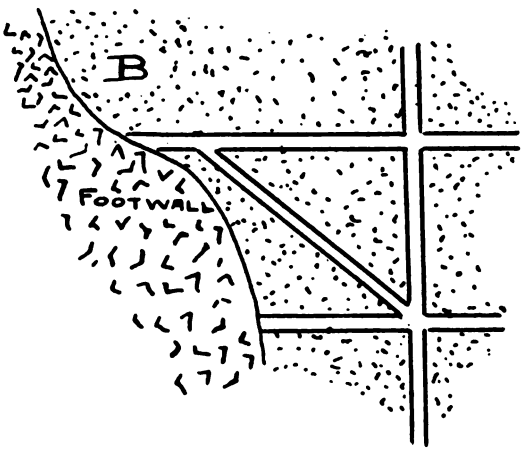

FIG. I.

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not be undermined by the workings on the lower subs, and therefore would not be reached by vertical raises. Under such circumstances inclined raises were put up and the foot wall easily stripped. Sometimes it was even found necessary to extend an extra level between two subs and put in a series of inclines from a drift on the lower sub to tap this extra sub level. A track would be laid in the drift and the ore trammed from the inclines to chutes leading to the main level.

The statement made in a previous paragraph that each sub is a rough duplicate of the level below, is apparently contradicted by the map (Fig. 4) of the first sub above the 10th level, in which it will be seen that the ground is much more cut up on the sub

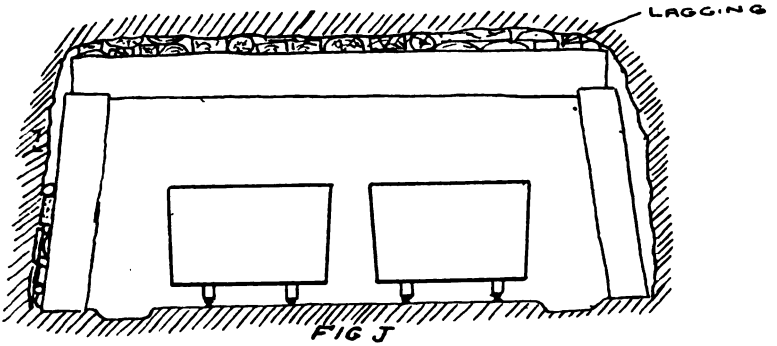

FIG J

than on the tenth. The difference is due to the fact that the pillars on the sub have been broken up by numerous cross-cuts which were put in to make the ground crush and so render the caving process easier. Needless to say the cross-cutting itself yields large quantities of ore.

The drifts used in the Pioneer mine are under most conditions about 8 by 8 feet in cross section. But on the main levels in cases where double tracking is necessary the dimensions are 10 by 18 feet inside of timber. This gives room for cars 6 feet wide passing with 2 foot space between them, and for sufficient ditching, etc.

The cross-cuts have the same size as the smaller drifts, namely, 8 by 8 feet.

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Raises are made with sectional dimensions depending on the work expected of them. Where large quantities of ore are to be caved down through a raise, or it is to be used for a timber hoist, its section will be 4 by 4 feet or 5 by 5. But if it is attacking a small piece of ground, as, for instance, some ore on the foot-wall, 3 by 3 feet is considered ample.

Inclined raises are put in at angles steep enough to make sure of the ore running well through them. The officials differ as to the minimum angle desirable, but the writer saw few if any satisfactory chutes inclined at less than 40 degrees from the horizontal.

Such in general is the mining process employed. Its effectiveness can only be realized by seeing it. The writer one day watched two miners of only average ability mine 150 tons from one cave, and the official stated that 300 tons were not infrequently the result of two men's work on good ground. When one remembers that this caved ore is discharged directly into motor-hauled cars without any shovelling being necessary, and that it is moved by mechanical devices to the smelters in Cleveland and Pittsburg and finally put on the market as "pig iron," all without any manual handling whatever, one gets an insight into the efficiency of modern engineering methods.

Needless to say the big output of such a mining system requires a very efficient system of transportation and hoisting. At first the company employed mule haulage, but as their output increased, electric traction was substituted and larger cars employed. At present three 5-ton, 30 horsepower motors are employed, two at a time in actual service and one as a reserve. A voltage of 250 is sufficient for the motors, and for the underground lighting.

The car employed has been designed for service involving manual tramming, electric traction and dumping into the shaft pocket. It holds 2¼ tons, and on a good track, two trammers can easily handle it loaded to that capacity. The body of the car is all steel. It has an inverted trough or gable bottom, and swinging sides which are held shut by longitudinal levers engaging with hooks. A blow disengages the lever and so discharges the car. All plate joints are braced internally by angle steel, and the

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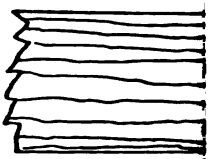

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whole is mounted on a spring truck not shown in the sketch, which runs on Anaconda axles and Lahlating wheels. The track is built to 2 foot gauge and 31 pound rails are used. Wherever possible the switches are automatic. Starting from the pocket, each motor passes around its circuit. At each cross-cut and at every point on the main line where chutes are full of ore, the trammer uncouples from the rear of the train as many cars as he and his partner can fill before the motor is back again, pushes them to their chutes, fills them and trams them out to the main line again. In the meantime the motor continues around the circuit, dropping empties behind it and picking up the loaded cars ahead as fast as the trainman can couple them up, so that finally it starts for the shaft with its train ahead of it, and all the empties distributed along its route.

The track way passes over the pocket and has a 2-foot dumping space on each side of it. Two men are stationed at the pocket armed with 4-foot steel bars. As the cars pass between them these men strike the levers with their bars and so dump the cars without stopping the train. Between the front end of the pocket and the end of the train-way there is room for 18 cars, which is therefore the maximum number in a train. Under very favorable conditions a round trip with such a train can be made in 15 minutes. Under average conditions, however, 12 car trains are brought in every 12 minutes by each motor, i.e., a train of twelve cars is unloaded into the pocket every six minutes.

The crew required to accomplish these results is as follows:

Pocket men	2
Trammers	16
Train men (2 each train)	4
Trackmen	2
Trammer boss	1
Total per shift	25 men

With an average output the cost per ton in wages with this crew is 3.26 cents. Lubricants, electricity, deterioration of plant, etc., probably do not make the cost exceed 3¾ cents to get a ton to the pocket.

The pocket has a capacity of 100 tons. It is discharged into two skips by a pocket stop shown in Fig. 5. It would seem

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that a pneumatic gate stop should be more economical, as the present system requires the attention of two men who receive relatively high wages, whereas the gates would work well with the kind of ore handled and could be easily managed by one man. The skips are of the usual type, and are designed to carry six tons.

Balanced hoisting is used, though the drums can be run separately if occasion demands it. The hoisting is done by a pair of Corliss direct motion engines with 26 by 48-inch cylinders, the drums being 8 feet in diameter with 5-foot and 6-inch faces, and grooved for 1¼-inch rope. Each carries 1,500 feet of rope, consisting of 6 strands, each of 19 crucible cast steel wires spun with the Langlay. According to Kemp's formulæ for the permissible load, P on a wire rope of n wires of diameter d, namely, $P=13{,}350\ nd^2$ we get as the tensile strength of such a rope about 44 tons. So that the rope is sufficiently strong for any acceleration the engines can give their loads.

The end compartment of the shaft is a cage road and the cage is used for lowering timber, tools and rock cars. It is hoisted by a simple direct motion, duplex Corliss cylinder 26 by 60 inches, drum 12 feet in diameter and 8 feet 6 inch face.

The men are hoisted at the changes of shift by means of the end cage, and in two double deck man-cages, which rest on the bales of the skips. While ore is being hoisted, these cages are hung on some small cranes in the shaft houses, and when required for man-hoisting each can be placed on the skip in about two minutes. They are, of course, provided with safety clutches and carry 26 men. The device certainly provides an economical means of quickly changing shifts without devoting the whole or a large section of the shaft exclusively to cage roads.

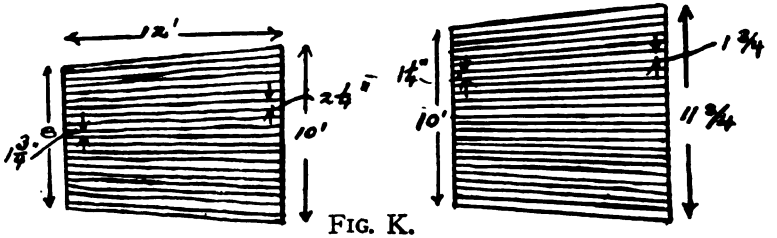

FIG. K.

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During the months of navigation the ore when hoisted is dumped onto two grizzlies of the dimensions shown in Fig. K. The larger lumps go through a No. 8 Gates crusher. The whole passes finally into hoppers, discharging into railway cars.

During the winter months, however, when shipment is no longer possible, all the ore is stocked in large piles. A substantial, though a simply built, trestle supports a track-way leading from the shaft head to the stock pile. During the winter of 1902-3 the ore hoisted from December 1st to March 27 amounted to 212,000 tons, all of which was stocked.

When navigation opens, stocking ceases, and the ore is loaded from the pile on to trains by means of 1½ yards Barbhart steam shovel. So far the company have been able to ship the annual pile by running the shovel during one ten-hour shift per day. Under average conditions 3,000 tons can be shovelled per shift.

Pumping.—The Pioneer cannot be said to be an excessively wet mine, but the ore body is naturally porous and the water percolates rapidly to the lower workings. Knowing this the company have decided to have a pumping station two levels below that on which active mining is in progress. For instance, they are at present working on the 10th level. Pumps will be put in at the 12th station and kept steadily at work, and the management expect that the development of the 11th level will as a result take place in dry ground. The pump will then be moved onto the 13th station to drain the 12th level, etc.

At present the water from the whole mine is being handled from the 10th level station by a Prescott duplex 16 by 8 by 12-inch pump which raises from 300 to 400 gallons per minute. The water from the 10th and higher levels collects by gravity into forks at the station which are also fed by pumps used in the shaft sinking. In A shaft a small No. 7 Cameron is kept on a temporary flooring in the timbering about 20 feet above the shaft sump, and is moved down as occasion demands it.

At B shaft it is the custom to suspend Cameron shaft sinking pumps in the shaft. The number required depends of course on the rate at which water is coming in at the point in question,

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and the distance of the shaft bottom below the station. At present the shaft is only about 40 feet below the 10th and one pump raises the water to the station, while a small Prescott duplex pump carries this water over the summit of a grade and discharges it into a ditch leading to the forks at the 10th level, A shaft, station.

Speaking generally the mine is kept dry. The men suffer no inconvenience at all from wet ground on the sub-levels and only to a limited extent on the main levels.

Shaft Sinking.—So far reference has been made to one shaft only, because all the development and hoisting has been achieved with that one. But a second shaft has been sunk on the other side of the syncline and is expected to develop that part of the ore body. It is being sunk at an angle of 70 degrees and is at present down 900 feet. In section it is 17 feet 6 inches by 6 feet and is divided into three compartments, two skip ways and a compartment for ladders, pipes and wires. As it has been sunk under no special difficulties, the method of sinking does not differ from that usually employed. It is interesting, however, on account of the fact that steel has been employed instead of timbers, and a section will be given below describing this steel lining.

In A shaft, sinking is being proceeded with while hoisting is going on, and these conditions have made necessary a system of sinking which deserves description. In section this shaft is 24 by 8 feet, and is divided into four compartments. The two central ones are skip roads, and through these at the time of the writer's visit the ore from the 10th level was being hoisted in six ton skips. As these skips were loaded from a pocket, there was a constant falling of rock down the shaft to the 11th station, and still greater danger was involved in the possibility of breaking in the hoisting plant. The disastrous effect of a 6 ton skip falling 1,000 feet can scarcely be estimated. To guard against this the following system has been employed. During the development of the 10th level the shaft was sunk as far as the 11th and a station S (Fig. L) established there. Chutes (C) were put in at the station to catch the leakage from the skips and this was hoisted on the small cage in the end compartment. Eight feet out from the shaft an inclined winze was put down from the floor of the station

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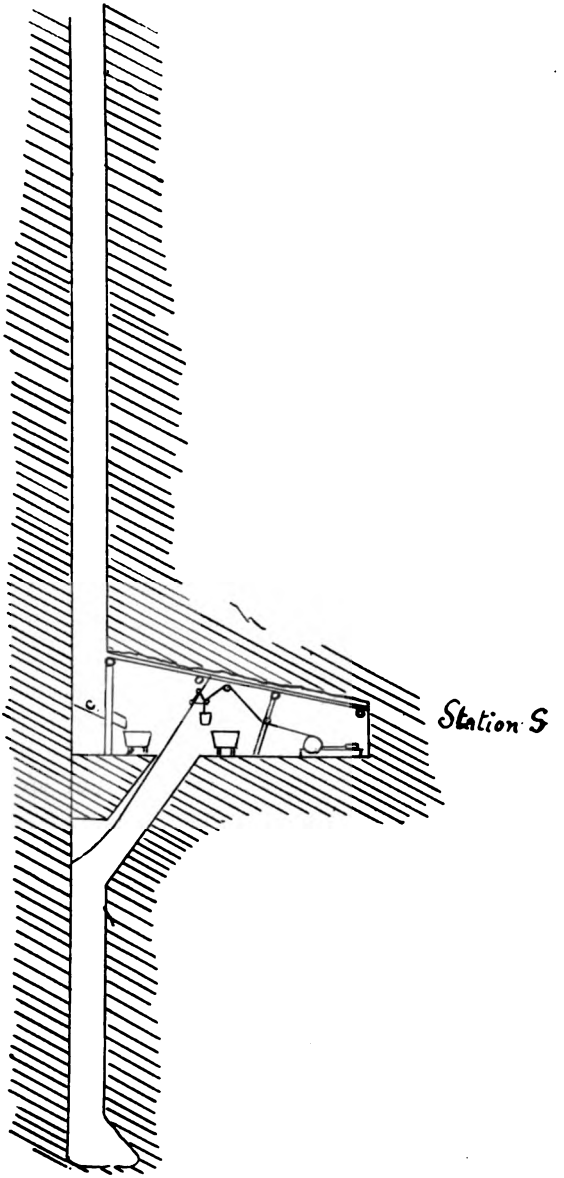

FIG. L

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until a rock pentice 12 feet in depth had been secured. The sinking then continued from that point. Under the surveyor's supervision 18-foot bearing pieces were put in exactly 24 feet below the lowest plates on the floor above and as the sets were four feet high, this provided for the introduction of six sets after the removal of the pentice. From these bearing pieces the subsequent sets were suspended and tightened into place as fast as excavation would permit and the sinking continued under these conditions until the twelfth was reached.

To hoist the rock as it was blasted a three wheel trolley was arranged in the winze, and a bucket was operated by a rope passing over the lower wheel of the trolley. To make travelling room for this bucket and for big timber, etc., the dividers were left out of the sets below the pentice and no difficulty was experienced in lowering heavy 24 feet caps for the 12th station by means of this arrangement.

Having reached the 12th level, the excavation of a station was immediately begun. Two heavy caps, CC (Fig. N), were put in to support the higher sets and the roofing of the station. Then, beginning at the side nearest the ore body, a small drift, DD, was driven off at an angle far enough to make room for one or two small rock cars, and another in a direction at right angles to the shaft until the point K, 48 feet from the rear wall plate, was reached. Then the ground was excavated along the line AB at right angles to DA, until room was made to put up the back set of the station, consisting of a 24-foot cap on two 9 foot props.

Crews were then put to work mining out the remainder of the station, the pump house and tramway, and the drift toward the ore body, while the shaft sinking crew proceeded to take out the pentice at the 11th level.

The rock blasted in these operations on the 12th level would soon accumulate too fast to be hoisted by the bucket, and moreover it was not desirable to have the timbering stand any longer without dividers than could be prevented. Therefore to get cars down to the new station and so dispense with the bucket way, the immediate removal of the pentice at the 11th was necessary.

Before actually attacking it the crew excavated a recess, R (Fig. M), past the end plate of the shaft so that 24-foot timber

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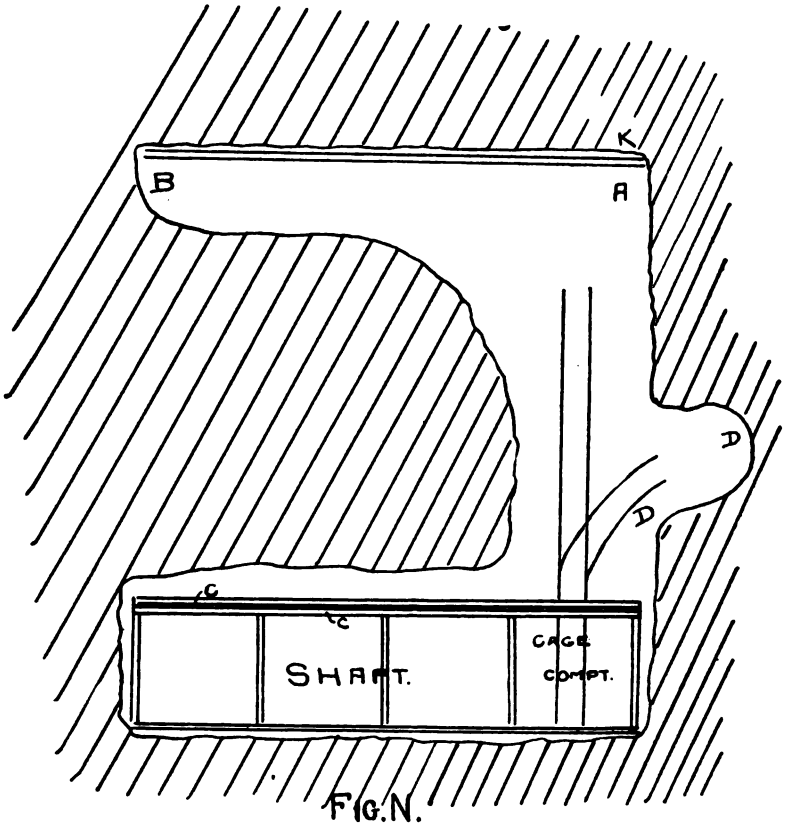

FIG. N.

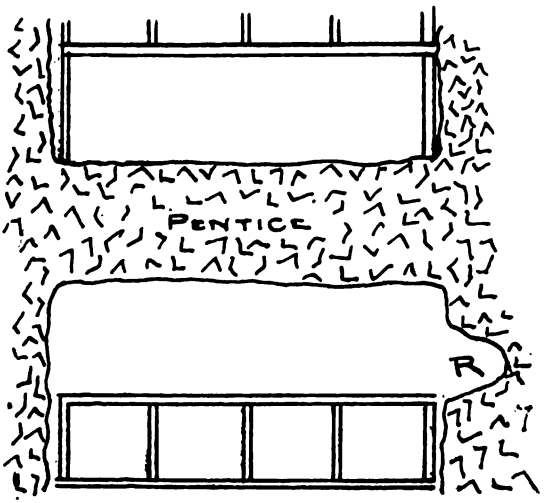

FIG. M

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could be lowered down by the trolley and swung into a convenient position for handling. They also covered the top set below the pentice with lagging in order to prevent the falling rock from injuring the timber below. Then drilling was commenced on the lower side of the pentice.

As fast as room was made sets of timber were put in and when the pentice was finally mined out, the timbering was continuous and the shaft practically ready for the cage and skips. The inclined winze and the space previously occupied by the pentice now afforded the pocket for station eleven.

The cage could now be lowered to the 12th station for rock, and work there proceeded with both in the drift and in the station itself.

When the development of the 11th level is going on the whole process will be repeated, a winze and pentice being put in at the 12th station, and so on as before.

Mention has been made of the steeling in B shaft. Realizing the rapidity with which the price of timber is increasing and the inherent advantages of steel construction over wooden, especially as a precaution against fire, the Oliver Mining Co. have introduced steel into three shafts at present being sunk, one of which is B shaft in the Pioneer.

In addition to studying the details personally I have referred freely to a paper by Mr. Frank Drake, the chief engineer of the company, who suggested and designed the lining employed. This paper may be found in the published proceedings of the Lake Superior Mining Institute, 1902.

Before reaching the solid ledge, B shaft had to be sunk through 25 feet of loose rock and gravel and for that distance the usual timbering was employed. From that point downward, however, steel sets were put into position and braced with studdles as will be described now.

The sets had to be designed for a three compartment shaft 6 feet by 17 feet 6 inches inside dimensions. The two hoisting compartments are 6 by 6 feet in section and contain each four 7⅞-inch gauge trackways with back runners provided to prevent the skips from leaving the tracks.

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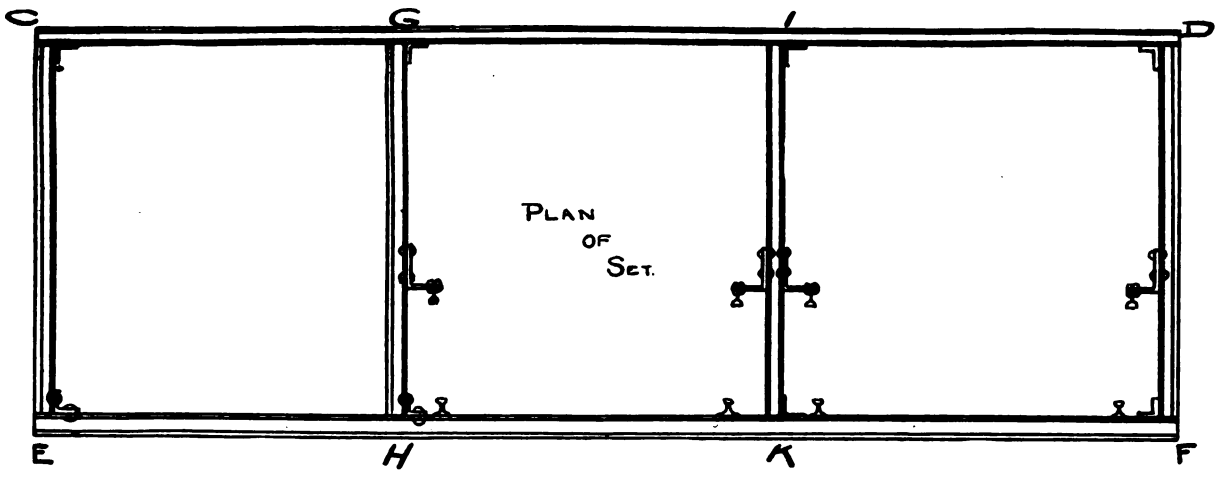

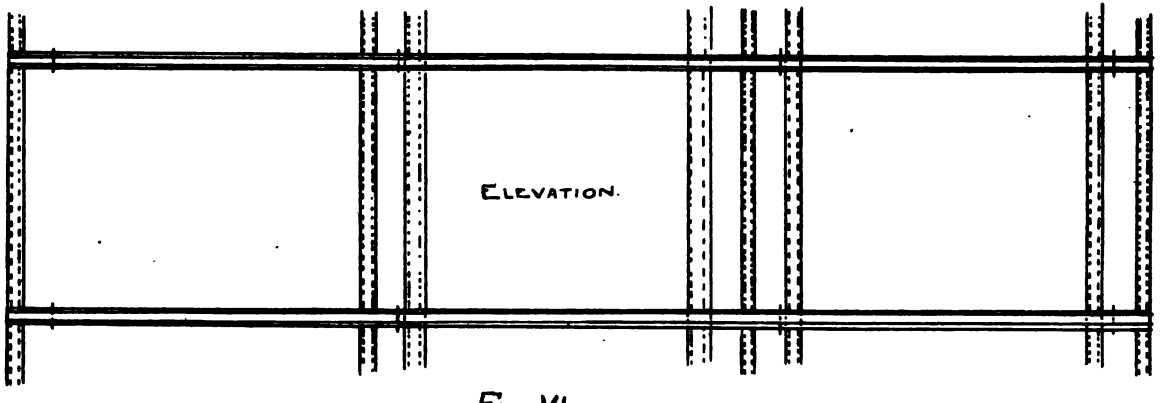

Fig. VI.

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To meet these requirements and sustain the stresses involv in operating five ton skips, a set has been devised whose form a general construction are shown in Fig. 6. CD and EF are t hanging wall and foot-wall plates respectively and are made 30 pound rail. CE and DF, the end pieces, and GH, one of t dividers, are made of 25 pound rail. IK, the divider between t skipways is made of 3-inch 7½ pound I beam, as the two flang are required on this piece to carry the back rail brackets, R Rails are preferred to I beams for the first mentioned pieces, cause for the weights required they are cheaper.

The connecting pieces which secure the various memb consist of 3½ by 3½ by ½-inch angle, 3½ inches long with t ½-inch rivets in each leg of the angle.

The back runners are suspended on 3-inch lengths of 8 8 by ¾-inch angle, rivetted to the end or dividing pieces w four ½-inch rivets.

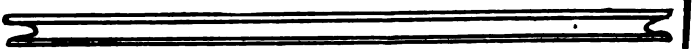

Fig. O.

The relative position of the sets is maintained by 8 stud engaging with the sets at the junctures of the wall plates the end and dividing pieces. These studdles are simply 4- lengths of rail, slotted at the ends as shown in Fig. O.

They are fitted to the members in such a way that move is only possible in the improbable event of the studdles ben To show this fitting a plan and sections (Fig. 7) are given o joint between an end piece and a wall plate. In the plan equals the end piece, WW the wall plate, and S the horiz section of the studdle. It will be seen that the end of the stu rail points toward the inside of the shaft, and presses against web of the end piece between the head and flange. Manife the studdle cannot move in a direction parallel to the wall p

On the other hand, reference to the section CD where is the end piece, W the section of the wall plate, and SS studdle, will show that the slot in the latter fits over the fla

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of the wall plate and so prevents the studdle from moving at right angles to the wall plate. In most cases 16 pound rails were used for the studdle, but almost any weight would answer the purpose, and the shortness of the lengths required has made it possible to utilize many pieces otherwise only fit for the scrap heap.

Sollars and *Ladders* are of wood, and the supporting beams of the latter are secured to the wall plates by U bolts. The fire risk involved in having these of wood is of course insignificant.

Just as in the case of timbering, it is necessary to use bearing pieces at frequent intervals to take up the weight of the lining. These consist of 30 pound rails extending across the shaft under each of the end and dividing pieces of the set. There are thus four bearers used at a time. They rest in hitches, cut in the walls on cast iron chairs of the form shown in Fig. 8. They are secured in position by wedging.

A very ingenious device was employed in lagging the first few hundred feet of the shaft. Here the rock was firm and no small pieces were likely to fall from the walls. No difficulty was therefore experienced in sinking 100 feet at a time without lagging. While this was being done old wire rope from the surface works was cut into 100-foot lengths and attached to hooks. With these hooks the ropes were suspended from the wall plates or end pieces and were hung between the sets and the rock. By means of a block and tackle they were stretched tightly downward, clamped at their lower extremity to hooks, and the latter sprung over the wall plates or end pieces 100 feet below. The distance between centres of the ropes is 5 inches and lateral movement is prevented by putting wooden wedges between the ropes and the rock at each set.

Ultimately, however, the ground at greater depths proved to be less secure and the lagging was done with 2-inch plank. Metal lathing would have been fireproof, but was too expensive. So as a compromise it has been proposed to introduce 16 feet of metal lathing in every 100 feet of wooden lagging. The writer cannot feel otherwise than sceptical concerning this expedient, for with the draft which will exist in this shaft, 16 feet of fire proof mater-

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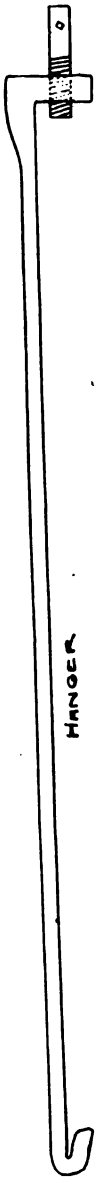

Fig. P.

ial seems a very trivial barrier to the spreading of even a small fire.

The set described above is assembled and rivetted in the shops. The steel is bought sawed to the required lengths and the rivetting is facilitated by preparing a ½-inch steel template for each kind of member, i.e., one for the wall plates, one for the transverse pieces, one for the angles and one for the back runner brackets. These templates are applied to the members and a pneumatic drill passed through the template holes. Thus there is no need for measuring and marking out the rivet work.

The studdles are made by heating the required length of rails and cutting out the slots with a chisel or die.

With these arrangements it is easy for the blacksmith force, in addition to their ordinary duties, to make and assemble all the sets as fast as they are needed.

The process of putting the sets into position is comparatively simple. They are lowered on a truck especially designed to carry each set with its long dimension extending downward and its width lying along the diagonal of the compartment. At the bottom each set is suspended from its predecessor by eight hangers of the form shown in the sketch, Fig. P, and is brought into approximate alignment by blocking. A studdle is then put in at each joint between wall plate and end of dividing piece and the set is tightened up against these studdles by means of the screw on the hangers, and wedged carefully into line by wedges put behind the joints in the frame of the set.

This is repeated until 8 or 10 sets are in position and then the skip and back rails are attached. The lengths, which are standard as rolled in the mills, are aligned carefully and are prepared for rivets by means of a No. 3 Boyer pneumatic drill, which drills through the flange and wall plates direct.

The back rails do not require such perfect alignment, so the supporting brackets are drilled on the surface. Hence it is only necessary underground to pass the drill through these holes and thence through the flange of the rail.

For many successive sets, the weight is temporarily supported by the hangers and the wedging. But as soon as the character

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of the rock demands it, bearers are put in. Their position and arrangements are shown in figure 8.

When they are in place, the hangers are removed and used in proceeding with the sets below.

The nature of the ground is such that the minimum distance between bearers so far has been 50 feet and the maximum 140 feet.

Mr. Drake's paper includes some very interesting statements as to the cost of this lining, and some of the details deserve repetition.

The cost of the material for making one set is $18.02 and the labor involved amounts to $5.15.

As was mentioned above, it is proposed to employ 16 feet of metal and 84 feet of wooden lath in each 100 feet of the shaft. Mr. Drake has prepared a table giving estimates of the cost of material per foot of shaft, in this case, in a case with wooden lath, and in a case of wooden lining throughout, which is as follows:

COST OF LINING PER FOOT OF SHAFT.

Items of Cost.	Steel Sets.		Wooden Lining Throughout.
	With Wooden Lath.	Wooden Lath and 16 ft. of Metal.	
1. Cost of sets	$5 79	$5 79	$3 10
2. Cost of bearing members and chairs	0 41	0 41	0 17
3. Cost of hangers	0 23	0 23	0 11
4. Cost of lath	2 12	2 73	2 35
Total	$8 55	$9 16	$5 73

This lining, somewhat of an innovation on this continent, was one of the most interesting features studied by the writer. It remains to be seen whether its designers have actually estimated the stresses which the members will suffer during the wear and tear of service. In timbering, most engineers probably evade the difficulty of investigating the shocks and stresses by simply using

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a very large factor of safety. I am unable to state whether Mr. Drake has simply designed a steel structure theoretically equivalent to the wooden one which it is customary to put in such a shaft, or whether he has ignored this construction entirely and based his design on the service stresses themselves. In either case the mere novelty of the steel set provides ample chance of error. The problem is made complex by such considerations as vibration, varying skiploads and velocities, wall pressure, etc., and only the test of time will show whether every structural detail from the 30 pound bearer to the ½-inch rivet will do the work expected of it.

Drilling and Blasting.—I have referred already to the large quantity of ore mined without machine drilling. In fact the whole outfit at the Pioneer includes only 33 machines and probably not more than 25 are ever in actual service at once. The type used is the 3B Little Giant Rand, and in practically all cases the machine is mounted on a tripod.

Each machine is numbered and allotted a set of drills (amounting to 25 or 30) similarly numbered. One man from each machine crew brings down the sharp tools from the smithy at the beginning of the shift and carries the dull ones to the station to be sent up. In ordinary ground, from 8 to 12 bits will be dulled per shift.

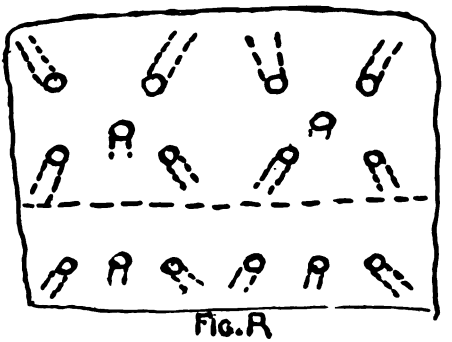

FIG. R

The arrangement of shot holes is very simple. This is roughly indicated in the sketch, Fig. R. The upper two-thirds of the face is mined out first, and the bottom then blasted with water

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holes. A crew generally drills for half a shift, blasts at dinner time and mucks out the ore during the remaining time. A more economical arrangement is to have a crew in charge of two faces, and while they are drilling in one, shovellers are mucking out the other. In this way the more costly labor is used only for machine work.

The uses of the tripod are too well known to deserve any detailed reference. The miners develop no little ingenuity in rigging up for almost flat bottom holes on staging in raises, etc.

The writer worked with a "Cousin Jack" in a large 10 by 20 drift during the first month of his stay, and of course a crew worked on the alternate shift. During this month the face was advanced 82 feet. Allowing eleven cubic feet to the ton this makes the amount of ore mined during that period 1,500 tons, or 25 tons per shift. And this is probably an average performance under such conditions. The actual drilling was of course intermittent, being interrupted by mucking and almost daily timbering.

Lighter machines (say the No. 2 Rand, for instance) would be very acceptable to crews working in the numerous raises, but the company no doubt regards this question from a different standpoint.

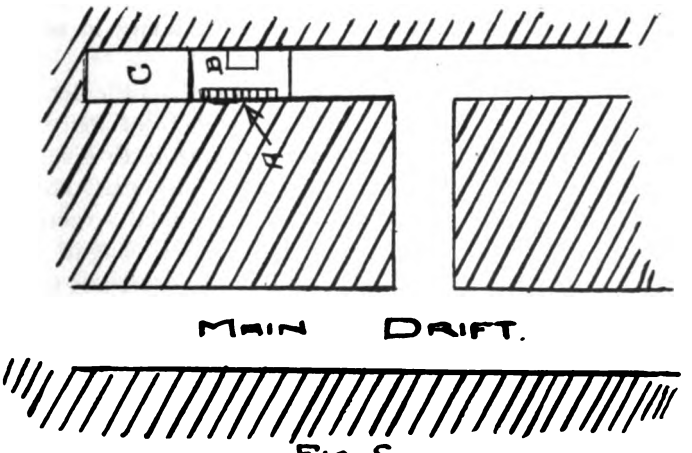

FIG. 5.

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The power for the drilling is delivered from an Ingersoll Sergeant, single stage double air compressor with Corliss duplex engines, steam cylinders 18 x 42, air cylinders 20 x 42, drill-power rating 30.

The explosive used for all general purposes is 40 per cent. nitro glycerine. It is brought down in quantities amounting to the daily consumption, and is thawed at a powder house on the main floor. This powder house consists of a double compartment room in a drift whose position relative to the main drift is shown in Fig. S. In the inner compartment, C, the powder brought down for 24 hours consumption is stored. In the outer compartment, B, is a dry cupboard for fuses and caps. A is a row of water furnaces over which the powder is thawed.

An intelligent man is in charge of the shift and his duties consist in cutting the fuse into two foot, four foot and five foot lengths affixing the detonating caps, thawing out the powder, issuing it to the miner, and keeping a record of the consumption during his shift.

The powder is issued through a small wicket, and each miner presents an order from the boss on his level for so many sticks and fuses. In this way supervision is exercised over the quantity used. And as no one is allowed in the powder house but the man in charge, and as he has electric lamps in both his compartments safety is assured.

Surface Plant.—Speaking generally there is little about the surface lay out of the Pioneer to distinguish it from any modern mine plant. Unfortunately the writer was unable to give much time to a study of the boilers and engines. The shaft house at A shaft is the typical frame, somewhat pyramidal structure so characteristic of the South Shore mining region. But in all the shaft houses the company is at present erecting, steel and modern structural designs have supplanted this old type. The new house at B shaft will be all steel, and designed along the general lines of two houses just completed by the company on adjacent properties.

The smithy and machine shops are well equipped, the equipment being as follows:

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Vertical Engine, 40 H.P.
Buffalo Blower.
24" x 14" Lathe.
Bradford Mill Engine Lathe 18" x 10'.
Pipe Cutter for 2½ to 8" pipe.
Planer 24" x 24" x 6'.
Drill Press 34' swing.
Bolt Cutter—dies, and taps ⅜" to 2".
600 lb. Steam Hammer.
Twist Drill Grinder.
Emery Wheel.
43" Hand Power Bending Rolls, capacity ½" plate.
One Doty Shear.
One No. 3 Boyer, Pneumatic Piston Drill.
One Pneumatic Rivetter ½" to 1".
Four Forges and one Levelling Block.

The crews are as follows:

(1) Machine shop; day shift only:—
Master mechanic
Foreman (runs one lathe)
Lathe runner
Drill Press operator
Bolt cutter
Plainer and drill operator

(2) Smithy
Day Shift:—
Foreman
Two drill sharpeners
Two general smiths
Night Shift:—Four drill sharpeners.

As far as I could estimate about 600 drills are sharpened in the 24 hours, and putting the wages of the sharpeners at $12.00 for that period, we get 2 cents as the cost of sharpening one bit. Or taking the average daily output as 2,500 tons, we get the cost per ton to be 0.48 cents in wages, say 0.5 cents including fuel, etc.

I have purposely omitted any detailed reference to the timbering, thinking that a set of sketches would be self-explanatory. Save in the case of shaft linings, and raise cribbings, the timber is all framed underground, as the framing required is not so complex as that of square sets. Shaft timber is prepared by the surface carpenters and the cribbing is cut by a pair of swinging saws driven by the machine shop power, and operated by one sawyer.

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Labor.—Except for a saving remnant of "Cousin Jacks" (Cornishmen) the men are all foreigners. Of the mine force about half are Austrians and half Finlanders, and as no great love is lost between the two factions a labor union is impossible. The pay ranges from $1.80 to $2.00 per shift. As is always the case with foreign labor at such pay a large staff of officials is necessary. They are as follows:

Superintendent.
Mine Captain.

Shift captain	for	each	shift.
Main floor boss	"	"	"
First sub	"	"	"
Second sub	"	"	"
Third sub	"	"	"
Timber boss	"	"	"
Trammer boss	"	"	"

With this staff the 300 men employed per shift is kept from any undue "tapering-off."

If there is any disadvantage connected with the general system of mining it lies in the fact that adequate measurement cannot be made of each man's work and so the contract system cannot be applied. True, each chute is numbered, and its discharge reported each shift by the trammer boss. But as one chute may be handling a product of two caves and perhaps some drifting or cross-cutting on a floor beneath, it does not afford a constant means of estimating the work done in any one of these places. But the wages paid are, relatively speaking, low, and the number of officials ensures fairly rapid and continuous work, so that perhaps the company gets almost or quite as good a return for its expenditure in wages as would be secured by the contract system.

And at all events it would be hard to conceive of cheaper mining for the conditions involved. In July of 1903, 75,000 tons were hoisted at a cost of .5109 cents per ton, and this cost never rises above 55 cents. The margin of profit must therefore be a large one, even when all expenditure in bounties, transportation and blast furnaces is considered. And if the affairs of the United States Steel and Iron Corporation, at present so perplexing both to shareholders and the general public, are fairly put on a sound

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basis, the Pioneer should surely prove to be one of their main sources of high grade raw material.

It is impossible to conclude without a reference to the fact that this highly productive deposit is within fifteen or twenty miles of the Canadian boundary. Mr. Van Hise, who is beyond doubt the geological authority on the Lake Superior region, believes that even the more extensive glacial erosion on the Canadian side cannot have robbed us of the ore bodies which should occur in Ontario in the Hunter's Island district if geological analogies are at all conclusive. How badly such a deposit is needed, anyone conversant with the present state of affairs at Sault Ste. Marie will realize. And perhaps if scientific exploration of that district results in extensive discoveries it will be found that no more economical mining process can be employed than one similar to that of the Pioneer mine.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

MAJOR LECKIE—The details given in the paper are highly interesting, and I hope that deposits found on the Canadian side will be developed as systematically as those found in the vicinity of the Pioneer mine.

DR. PORTER—The method does not differ in principle from that employed in the other mines, but, owing to the system followed, there is less waste and less loss. I think the paper when printed will show very few novelties, but is a clear definition of the system in its best development. In reading the paper I tried to select the more novel portions of it, but I omitted over half of it.

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Journal of the Canadian Mining Institute, Vol. VII.

NOTES ON THE BRITISH COLUMBIA ZINC PROBLEM.

By Alfred C. Garde, M.E., Sandon, B.C.

Toronto Meeting, March, 1904.

PREAMBLE.

In submitting the "Zinc Problem of British Columbia" as a topic for discussion I desire to state that I have been encouraged in doing so by observing the keen interest manifested by the silver lead miners and others in determining the best methods for treating and handling the extensive bodies of zinc-blende found in ledges as well as deposits over a considerable section of the province.

I shall be only too willing to admit that this subject on account of its importance and certain complicated features deserves to be dealt with by a more experienced pen than mine. I expect that this, in due time, will be done, but in the meantime I believe that a starting effort would not be out of the way, for even the best authority would find it to be an endless task to suggest the proper remedies unless all features of the subject had been clearly described. In some instances I have been obliged to draw conclusions from unsettled conditions, and these will no doubt be subject to change when a more definite base is reached. At the same time, I hope that the friends of the Canadian Mining Institute, including my friends in British Columbia, who are particularly interested in this matter, will bear in mind that this treatise is the first one to appear in Canada on the subject, and that all records and data therefore had to be collected chiefly by personal observation. If I should succeed in pointing out the principal characteristic elements and be permitted to offer the following notes for discussion, my present object will be achieved, and I venture to hope that the initial step towards the eventual solution of this most interesting problem will thereby be taken. The

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features involved are as much of an economic as a technical nature, and I have mentioned elsewhere that a great many of them can and will be overcome by individual efforts of companies operating in British Columbia. After wrestling with the zinc problem single handed for more than a year, the Payne Mining Company, under my management, decided to erect a special zinc dressing plant, and are now in a position to produce from 200 to 300 tons of desirable zinc concentrates per month. Markets for the various products have also successfully been established both in Europe and the United States, and steady shipments are now being made. Since then other companies have followed suit and there are a number of zinc shipping mines on the list now. Besides, several of the old mills are now being re-constructed with the view of treating their zinc ores on a commercial scale, which points favorably towards an increased production of this useful mineral.

HISTORY OF EARLY ADVERSITIES

In order to clearly understand the present situation in British Columbia it will be necessary for me to relate briefly the early history of the Ainsworth and Slocan districts, being the first mining divisions in West Kootenay to record discoveries of zinc and lead. Both districts came into prominence approximately twelve years ago on account of their remarkably high grade ledges of silver-lead ores. Zinc-blende was also found in ledges and in association with galena, but for ten years not the least regard was paid to the economic features of zinc. Only in one instance a certain Mr. Brown, of Manchester, in 1899, undertook to send an experimental shipment of 1800 tons of zinc-blende from the "Lucky Jim" mines near Sandon, to one of the zinc smelters in England. The assays of this shipment averaged 50 per cent. zinc, 3 per cent. lead, and 6 ozs. in silver per short ton. Unfortunately Mr. Brown died in England before the shipment reached its destination, and his well intended project came to grief with him. I have not the least doubt that if he had had an opportunity to carry out his plans, our zinc ores would have had an established market five years ago. Since then the "Lucky Jim" mine fell back into

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obscurity; however, it is well worth noting that this property has recently been secured by local parties for a large cash consideration, and is now generally regarded to become one of the largest producers of zinc-blende in the Slocan. The chronicle of this mine as well as the assay values of shipment mentioned will illustrate better than can otherwise be explained, how entirely the zinc industry in British Columbia has been overlooked, and also what may be expected from it in time to come. It may possibly be argued that in the upper ore zones extending towards the crest and along the surface of the mountains, only a small percentage of zinc was found to be associated with the galena. This feature, however, can readily be explained as caused through corrosive action of surface water and exposure to the elements, whereby the sulphides of zinc (and to quite an extent the sulphides of lead) were changed into carbonate ores. The carbonates with average contents of 80 ounces of silver, 40 per cent. of lead and low in zinc, furnished an excellent smelting product on which the smelters did not impose any zinc penalty.

In several of the mines familiar to me the carbonates and galena ores free from zinc extended to a depth of 4 to 500 feet below the apex of the mountain, but by degrees a material percentage of zinc-blende made its appearance. In most cases under my observation this transformation would take place gradually, although I am aware of numerous instances where the zinc-blende has replaced the clean galena abruptly and *vice versa*. The result of the steadily increasing percentage of zinc was that the lead smelters found it necessary to place a penalty of 50 cents per unit on galena containing more than 10 per cent. of zinc. This penalty was accepted by the high-grade miners of Sandon who were in a position to ship a galena product averaging from 80 to 90 ounces in silver and 45 to 50 per cent. lead. As an instance, I might quote that during 1900 the Payne mine shipped 10,411 tons of galena averaging 83.79 ounces in silver, 45 per cent. lead and 15 per cent. zinc, and that the penalty paid on zinc alone during this year amounted to $28,203.42, being equal to a deduction of $2.71 per ton of ore shipped. Other mines had similar experiences and

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found that the zinc contents in spite of close hand-sorting could not be kept within the 10 per cent. limit, and that different means would have to be resorted to in order to keep the galena free from excess zinc. To overcome this difficulty mechanical concentration by water was eventually applied. A number of 100 ton mills generally driven by water power, and nearly all constructed on the same plan, were built in a comparatively short time. Hartz jigs with two or sometimes three cells were used in separating the coarse galena from the waste rock as well as the zinc-blende and iron, all of which went through the tail-races. For the finer lead products buddles and Frue Vanners were used. The system of concentration employed often left much to be desired as to efficiency, but the point of keeping the galena contents within the zinc penalty limit was gained. From the above it will readily be seen that one of the essential features of concentration in the Kootenay was to send as much zinc through the tail-races as possible, and it must be admitted that this aim was carried out to a high degree of perfection. The tonnage of zinc thus wasted was immense, and its extent will probably never be known; it can only be roughly estimated from assays of the tail products which would often exceed 30 per cent. zinc and rarely go below 20 per cent. A considerable amount of silver contained in the blende also went into the various creeks with the tailings, but so as not to get myself into hot water I prefer not to quote any assays.

In summing up the various losses, we have:

1. Direct loss to the mines due to zinc penalty payments.
2. Loss of zinc values in smelting lead ores high in zinc.
3. Loss of zinc and silver values run to waste through the tail-races of the various concentrators.
4. Hand-sorted zinc ores left on the dumps or in the old mine stopes.

Of the above losses the fourth item is the only one that can partly be recovered, providing the material is present in sufficient quantities to permit of economic handling and concentration. At

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the Payne, the Ruth, the Ivanhoe, the Wakefield and the Alamo concentrators, this is being done successfully now. Furthermore, the Slocan Star, the Washington, the Jackson, the Monitor, the Rambler and several other well known properties are now preparing to alter their present plants or erect new ones whereby they will be able to recover the "zincy" material on hand, as well as all zinc that in the regular course of mining is broken down with the lead ores. In order to give an idea of results that have been obtained I may state that during the first ten months' run (May, 1902, to March 30th, 1903) the Payne concentrator handled 33,000 tons of old and 7,000 tons of new stope fillings, from which 1,247 tons of high-grade silver-lead concentrates were derived and sold to local smelters. In addition hereto 1,391 tons of 42 per cent.—43 per cent. zinc blende concentrates, containing 8 ounces in silver, were produced as a by-product at no extra cost. A 1,000 ton lot was disposed of to the Lanyon Zinc Company, of Iola, Kansas, and netted the Payne Company, after paying an $11 freight rate, $8 per ton. Encouraged by these results the Company at once added a magnetic separating plant, whereby they have been able to, at a cost of from $1.50 to $2.00 per ton, improve the zinc product from 42 per cent. to 55 per cent. This plant has now been in successful operation for the past four months and will no doubt be followed by other companies ere long.

For a moment we will leave the "high-grade" mines of Sandon, located at elevations from 4 to 8,000 feet, and see how the Silver-Lead-Zinc mines, situated at altitudes ranging between 1,700 and 4,000 feet, fared in reference to the zinc question. Here we find that the ratio of silver in the galena is of much lower tenor, or approximately one-half ounce of silver to one per cent. of lead, while in many instances the percentage lead contents is low and the percentage of zinc high. In the Kootenays an ore of this class is termed "low grade," and it will readily be understood that on these the penalty of zinc worked a severe hardship. In addition hereto the price of silver continued to decline, and when the American Smelting & Refining Company, in January, 1900, withdrew from the Canadian lead market and compelled the producer in Canada to sell

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his lead at much lower prices in the continental market in competition with cheap Spanish and Mexican labor it was not to be wondered at that the "low-grade" mines were obliged to shut down. To some considerable extent this last feature has been overcome within the past eight months by the liberal bounty of $15 per ton granted by the Dominion Government for five years on all lead mined and smelted in Canada. The bonus has particularly proved of great benefit to the mines in a position to produce a heavy lead ore or lead concentrates, but in order to re-open the low grade lead-zinc mines it will first be necessary for the owners of same to make a by-product of the zinc, which may be disposed of at once—if of sufficiently high grade to stand present freight charges—or stored until such time as zinc smelting works will be erected in British Columbia.

I have, in the above, aimed to show how the zinc industry gradually succeeded in struggling ahead. Kind reception could not be expected. For years the zinc had been looked upon as a mongrel intruding upon the peerless silver-lead ores. Was it possible that the black stuff, found everywhere in the mines and on the dumps, possessed any value, and, if so, how was it that it had been wasted by the thousands of tons during a period of over ten years when prices of spelter in London and New York continued to soar higher and higher? Of all the difficulties that have been thrown up against the industry since its infancy, the very feature of even being tolerated was by far the most difficult problem to overcome, and it seemed that those who had done the least to stop the wasting of it were the least anxious to help it along, and the first ones to clamor about difficulties, many of which were either false alarms or have since been solved.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

THE PRESIDENT—This is no doubt a very interesting problem, as by-products very often form such valuable assets. Professor Miller who has had to do with the only working zinc mine

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in Ontario, can possibly give us some more information. I did not understand from the paper whether the minerals were intimately mixed or are in a coarse state.

PROF. GWILLIM—This paper does not say that, but I think they are intimately mixed.

PROF. MILLER—This problem of separating zinc blende from galena has been under consideration for a great many years. One of the most important deposits in the world is at Broken Hill, N.S.W., and the proprietors are stated to have offered $50,000 to any man who would devise a process that would treat their ores successfully, but I do not think they have reached a very successful method of treating them yet. The mine ore which is being worked in Ontario, and which has now been a producer in a small way for two or three years, is somewhat different from this British Columbia ore. Instead of having 50 per cent. zinc in the ore we have 40 per cent., and instead of having 3 per cent. lead we have usually 12 per cent. to 15 per cent. lead, and we found when we first investigated this ore, that the galena carried 20 ounces silver; the zinc blende carries no silver. This ore, unfortunately, has not been treated in this province except in a crude way.

It is shipped in bulk to Swansea or Germany and treated there, and of course it has to be sold at a lower price than if the minerals were separated. We would be getting $50 per ton for the galena if it were separated and $30 or $35 a ton for the zinc blende. As they are mixed we are only getting $15 or $18 a ton for the mixture, running 40 per cent. zinc and scarcely anything is paid for the lead and nothing is paid for the silver. This is an important problem for us in Ontario, as I think we have other deposits.

PROF. GWILLIM—Does Professor Miller mean that you can get 40 per cent. zinc by rough jigging? With regard to the silver contents of the Payne mine, Mr. Garde states that the purer he got the zinc the less silver there was, and I think that is true at all of these mines. There is a closer association between galena and silver than there is between zinc and silver. I think by Mr. Garde's process he takes the iron and not the zinc out of

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the ore, which would show that there is not much galena in it. Mr. Garde speaks of not getting very much zinc until he gets down 500 feet, and I know that was the case in the early history of that district. The zinc in the original ore is apparently concentrated lower down, leaving the galena at the surface, and that I think has happened elsewhere. I would like to know if they are going to pass through that zone and get something else below, that is, will the ore be more or will it be less zincy than it is at present?

PROF. MILLER—The galena is found in greater quantities near the surface. I do not think they will meet a zone of lead ore beneath their present workings.

THE PRESIDENT—It is encouraging to learn that the zinc blende and galena mixture shipped from Ontario brought $18 a ton, though the much higher values mentioned by Prof. Miller, as obtainable by separating the metals, plainly show the importance of this problem.

PROF. KIRKPATRICK—I do not think the problem is nearly so complicated with us as in the case of the Broken Hill deposit, because our ores are certainly not so intermixed. I believe they are experimenting on magnetic separation of the zinc blende from the galena, and if it succeeds it ought to give very fair results. I happen to know that in Leadville they are separating the galena from the zinc by a magnetic separator.

PROF. GWILLIM—Mr. Garde mentioned that Mr. Brown was looking for zinc ores in that country. Mr. Brown did not want the zinc ores, as you might suppose, with very low value in silver; he wanted ore that was high grade in silver and he would have had it in the Enterprise mine, which is very rich in silver. The Lucky Jim is not especially high grade in silver, although it shipped some high grade silver-lead ore besides the zinc in 1895.

THE PRESIDENT—I quite understand that a man would prefer to get silver more than zinc, because zinc is one of the most refractory and nasty minerals in combination to treat. Silver is the easier proposition of the two.

I would like to hear something from Mr. Snyder on the magnetic separation of these zinc ores.

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MR. SNYDER—I do not understand whether the B. C. separation is the lead-zinc separation, or whether it is the zinc-iron separation. Generally the lead comes out without difficulty in the ordinary water process.

PROF. GWILLIM—Mr. Garde's chief problem seems to be to separate the zinc from the iron and gangue. He roasts the ore and takes the iron out after the roasting. Perhaps he separates the lead from the zinc by water, but anyway he gets a product of about 55 per cent. zinc.

MR. SNYDER—The problem at Leadville is very much simplified by the fact that the zinc is ferruginous and is sufficiently magnetic to be attracted, leaving the lead in combination with the iron and silver. In the southwestern district of Wisconsin, they have the same iron and zinc combination, but in this case the zinc blende is not sufficiently magnetic to be treated by a separator of a practical commercial size, so the ore is roasted and the iron sulphide is changed either into pyrrhotite which of course is highly magnetic, or is roasted further into oxide. The great difficulty in roasting zinc ore for the purpose of magnetic separation is the fact that after you roast it it is all the same color, and it is very difficult to tell by looking at it what you are doing. If you are able to separate it magnetically before it is roasted, the difference in color is sufficient to enable a person who has experience to tell pretty nearly what the analysis is. In Australia a good deal of the ore can be handled without roasting, although they have been roasting some of it. There the great difficulty is the small size of the crystals, and the intimate way in which the lead and zinc are crystalized. Everyone is trying to get an economic wet method, but the difference between dry separation and the customary water separation is that you do not lose anything in slime. At Leadville by dry separation about 15 per cent. of the ore is saved in the shape of dust, and that 15 per cent. pays a good share of the cost of making the separation, as it runs high enough in zinc to be sold as part of the zinc product.

PROF. MILLER—In what way have you saved that?

MR. SNYDER—By putting it over a separator which we have for the purpose.

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Journal of the Canadian Mining Institute, Vol. VII.

UNDEVELOPED MINERAL RESOURCES OF ONTARIO.

By Willet G. Miller, Provincial Geologist, Toronto, Ont.

Toronto Meeting, March, 1904.

Complaints, whether just or unjust it is not our province to determine, are often heard to the effect that our neighbors to the south have usually gotten the better of us in the various treaties and conventions which have been held between the two countries from 1776 onwards, but it is recognized by few that certain natural agencies, even before the time of Adam, were working in behalf of our neighbors, in an agricultural sense at least, and against us. A large part of the soil, which undoubtedly covered our now rocky areas at the end of the Mezozoic era, was transported to the southward, across what is now the international boundary, in the succeeding era by the ice sheet which completely covered the territory which we now call Ontario. What would have become, long ere this, prosperous homesteads and rich agricultural communities, were forever rendered impossible by the movements southward of the great glaciers, whose effects, greater than those produced by the greatest of invading armies, are to last through all time. While the Canadian agriculturist may regret that many a fertile plain and valley in the great Republic owes its prosperity to the stealing of our soil by the ice kings, his brother, the miner, rejoices that old mother nature in that far distant time was working for his benefit. By carrying away the soil she exposed the ore-bearing rocks to his view.

We hear a great deal of what heated waters and volcanic action have accomplished in the formation of ore deposits, but no one has yet come forward to champion the glaciers, to whose action in many parts of the world the mineral industry is so much indebted. They seem to have concentrated the gold in the far-famed Klondike; they have scoured many a mountain and plain, exposing the treasures in the rocks beneath; they have furnished

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us with many a lakelet and waterfall, and have rendered picturesque many a region whose landscape would otherwise have remained monotonous and unattractive.

It is difficult to state definitely what part of the 220,000 square miles embraced in the territory of Ontario possesses a rocky surface that is not well adapted to agriculture. It probably is about one-half. Over this broken region there are what have been roughly classed as two great groups of rocks, the Laurentian and Huronian. We have been educated in the belief that the Huronian is *par excellence* the mineral-bearing system of the two, and that the Laurentian, with the exception of the crystalline limestone and associated rocks of the Grenville series, was to be considered of little economic importance. Much of what we call the Laurentian system is composed of acid plutonic and metamorphic rocks —granites, syenites and gneisses. We have been told that these particularly, which occupy vast areas, were of very little importance, as the storehouses of economic minerals. Prospecting and development work during late years have, however, disproved the old belief concerning this series; and I look forward to further interesting mineral discoveries being made in these maligned rocks. Mica, which, with the advancement in electricity is likely to become still more important, is found in what appear to be economic quantities in many coarse-grained granites. Heretofore the mica mined in this province has been practically all of the phlogopite variety, which is found associated with apatite, calcite and pyroxene. The greater part of the muscovite used on this continent has been imported from India. One of the chief electrical firms of the United States is now planning the development of muscovite deposits in Ontario to replace that from India now used by them. This promises to become an important industry, as white mica is found in many localities from the western boundary of Quebec to the eastern border of Manitoba. Micanite has brought about the use of smaller sheets of mica than could be used a few years ago, and many of the muscovite deposits, considered of no value at that time, now contain merchantable material. Then these Laurentian granites are known to be the

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storehouses of many rare minerals, some of which have at present economic uses and others may be expected to have at no distant date. The only specimen of wolfram, the ore of the metal tungsten which is used in a steel alloy, ever found in this province was attached to a boulder of the heretofore much despised Laurentian granite. Again, the only deposit of columbite, a mineral which has recently come into commerce, occurs in a coarse grained granite dike. Within the last few years an important corundum industry has sprung up in one of these formerly so-called barren granite districts; the mineral has been found at numerous points in belts of these rocks, which have a known length in the province of about 100 miles. Other examples could be given to show that the larger, hitherto neglected, Laurentian granite areas are well worthy of the attention of the prospector. Enough has, however, been said to show that these rocky areas are not to be left unconsidered when estimating the value of our undeveloped mineral resources. They already furnish us with a greater variety of economic minerals than the Huronian and younger formations which in years gone by were the favorites of the prospectors. Our mineral-bearing areas are, therefore, much more extensive than they were formerly thought to be.

To worthily justify its title this paper should possess the size of a large volume. Our undeveloped mineral resources are extremely varied in character.

The writer showed in a paper published in Vol. V of the journal of this Institute* that Ontario produced as great a variety of minerals as probably any other area of the world of like extent. My object, however, is not to attempt a detailed description of these resources, even had time permitted, but to give a rough outline of the field that lies waiting for the mining man in this province. In order to do this systematically, but briefly, I shall use a classification, which has long been adopted by the Geological Survey, and divide the useful minerals and rocks into several groups.

* Eastern Ontario: A Region of Varied Mining Industries.—*Journal Canadian Mining Institute*, Vol. V, p. 233.

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1. Metals and their ores:

The ores of the following metals have been profitably mined in the province: gold, silver, platinum, iron, nickel, copper, lead, zinc. A small amount of molybdenum ore has also been produced. Most of the other metals, both common and rare, which are used in the arts are found here. For example, the richest ore of aluminum, corundum, is found, as already stated, over a large territory. This substance, however, brings a higher price as an abrasive material than as an ore, and is consequently not used for the extraction of the metal. Titanium, which appears to be destined to play an important part in alloys, occurs in numerous, at present undeveloped, deposits. Tin has been found in small quantities in the vicinity of Sudbury, and in Renfrew county. Mercury has been found at one locality, Silver Islet, in very small amounts. The metal tungsten, as already stated, has been found only in a boulder. Arsenic, the chief use of which is not in the metallic form, and other metals which are employed in the arts in the form of oxides or other compounds will be discussed under other headings.

Gold.—Considering the extent of territory over which gold deposits occur in the province, and the numerous areas in which prospects have had more or less work done on them, it must be admitted that we have large undeveloped resources in this metal. The present state of our gold mining industry is due chiefly to incompetent management, stock-jobbing and other speculative factors—the parasites which attack the industry in all countries while it is in a weak, undeveloped state. It is to be expected, however, that after the epidemic has spent its force, like those which at times attack our bodies, the industry will be in a sounder condition, and will soon reach such a state of healthy development that parasites will be ineffectual to injure it. Our President has stated that the most promising gold prospect he examined while in the service of the Geological Survey, in the Lake of the Woods area, 21 years ago, has lain untouched ever since, being tied up through the belief of the owners that they could make a profit through someone else's expenditure. Mr. Carter shows in his paper

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that we have nothing to fear from the deep development of our gold mines. Such factors give us confidence that the undeveloped state of our gold deposits is not due to the quality and amount of ore. We have, therefore, reason to place a value on our gold fields of the Hastings district, Wahnapitae, Michipicoten, Thunder Bay and Rainy River, as promising to be important assets in the future. Then there are the placer deposits which stretch for many miles along the Vermilion River, and those of Sturgeon Lake which cover a large area. Under more favorable conditions some at least of these areas should be worked at a profit.

Silver.—In the district surrounding the head of Lake Superior we have had one great silver mine, and a group of others which have produced a considerable amount of the metal. Five hundred miles to the east of this, across a region much of which is difficult of access, and practically unexplored, very promising silver deposits have recently been discovered. Is it not reasonable to conclude that the great intervening region, over a large part of which similar rocks occur, probably contains numerous undiscovered deposits?

Platinum.—The metal platinum, which is frequently associated with the noble metals, gold and silver, in nature, is found in the Sudbury ores. Unfortunately the most promising deposit of this metal yet discovered has lain dormant since its discovery for 15 years or more, owing to differences among shareholders—a cause which is primarily responsible for the undeveloped state of other important ore bodies in this province.

Iron, Nickel, Cobalt.—The areas occupied by rocks which give promise of containing workable iron deposits occupy a greater extent of territory than those in which there are fairly definite indications of any other metal. Neglecting for present consideration the older explored areas in south-eastern Ontario, the iron range formations which surround the Ontario side of Lake Superior and extend westward towards Manitoba, and eastward to the Quebec boundary, have an aggregate length of several hundred miles. As many parts of these ranges possess characteristics similar to those in the Lake Superior region of the United States it must be admitted that this

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province in all likelihood possesses vast undeveloped iron resources. It is to be hoped that they will not be tied up like some other of our mineral deposits. In the northern and western parts of the province there is only one iron mine which has been a producer of importance. This deposit owes its development largely to a favorable situation. As facilities for transportation are supplied to more remote fields others will undoubtedly become producers.

Their magnetic properties distinguish iron, nickel and cobalt from all other elements. The iron-bearing formations of Ontario are not less in extent than those of any other part of the earth of equal area. The province has only one competitor as a nickel producer, and her undeveloped resources in this metal appear to be unequalled. The deposits which have been developed form only a small percentage of those known to exist in the Sudbury area.

Cobalt does not come into commerce as a metal, but as an oxide. It is found in Ontario in deposits richer than are known to occur elsewhere. If the promise which the recently discovered deposits give is fulfilled, no country will be able to compete with this province in the production of cobalt. The market for the oxide of the metal is restricted, and our ores being so much richer than those found elsewhere should control the market.

Is there not something strange in the fact that this group of three metals—iron, nickel and cobalt—which possess properties different from all other elements should be found in unsurpassed quantities in this province? Have magnetic influences had something to do with their concentration? Or is it owing to the fact that in our province a large area of the oldest known rocks are exposed? Probably during the early period of the earth's history these magnetic metals occurred abundantly near the surface. More recent formations have been formed by the breaking down of these earlier formed rocks and the metals, especially nickel and cobalt, have been scattered. It may be said that our deposits of the three metals do not all occur in our oldest rocks. The eruptives, however, whether massive or fragmental, which are associ-

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ated with the deposits, were formed, in all probability, from material which existed not far from the early surface and had not been worked over by agents of denudation.

Copper.—Copper deposits are numerous in the territory bounded by the lower end of Lake Superior and the upper end of Lake Huron. Considerable development work has been done on these deposits during the last few years, and it would appear that a fair percentage of them will become producers. During the last decade or more, copper has been produced in association with the nickel ores of Sudbury. All these nickel deposits carry copper, and Ontario will in the years to come be credited, from the nickel mines, with a considerable amount of the metal now so much in demand for electrical and other uses. Another copper mine, that of Massey Station, has recently become a producer and the province has, chiefly, to thank the tireless energy and skill of that veteran metallurgist of this Institute, Major Leckie, for this much to be desired consummation.

Outside of the district embraced in the southern portion of Algoma and Western Nipissing the only copper property which has received serious attention is that which is now known as the Tip Top mine, west of Port Arthur. This mine has reached a stage of development which the owners consider warrants them in erecting a smelter.

The success already achieved in the copper industry, together with the knowledge that many deposits over a large territory, are as yet untested, should lead us to conclude that the province has a good future ahead as a copper producer.

Lead and Zinc.—The metals lead and zinc are commonly found associated in nature. Most of the deposits of these metals throughout the world are in rocks younger than the Archean, and from what I have said concerning the magnetic metals it might be inferred that lead and zinc would not be found in the province in large amounts. These metals show a tendency, however, to make their abode in limestones, wherever they can find them. In our Grenville

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series, crystalline representatives of these rocks are found, occupying large areas, and the metals occur at numerous points. The character of the deposits of these metals is, however, characteristically difficult to determine, and they are often hidden, owing to the softness and easy weathering of the limestone. Hence there is reason to believe that many of these ore bodies are yet awaiting discovery. Zinc deposits have been worked in both the eastern and western parts of the province. Work on the Lake Superior deposits ceased a couple of years ago, but a mine in Frontenac county has been producing ore in small quantities for two or three years, and can apparently continue as a producer for years to come. This latter mine illustrates what I have said about the difficulty often experienced in discovering deposits of the metal. It is situated in a cleared field in a part of the country which had been prospected for years without the deposit being located. That metamorphic or Archean areas are not to be avoided by those in search of zinc is shown by the fact that the great deposits of New Jersey are in limestone similar in character to those of our Grenville series. And although the great Missouri zinc-bearing rocks are not of Archean age still they are rather closely connected with these rocks. In that state, isolated nobs, representing peaks of mountains which rose from the Archean surface, project through the later sedimentary formations.

The lead deposits of Ontario are similar to those of zinc, and what has just been said will apply to them. We have, in Hastings county, one working lead mine, with a small smelter, and it is not unreasonable to suppose that other deposits, both known and unknown, will be worked in the future.

Having made this rapid survey of our metallic resources, I shall now briefly review the other groups of economic minerals found in the province.

2. Minerals used for grinding and polishing.

I have shown that Ontario has unsurpassed resources in iron and nickel, which form an alloy which is to be the metal of the 20th century. In the manufacture of machinery, utensils, and other articles composed of metal, a substance is needed to

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smooth down the rough castings and forgings. Mother nature, in furnishing us with these great metal deposits, did not forget to supply us with the mineral needed to polish the metal and put it into marketable form. Hence, she gave us the great belt of corundum-bearing rocks that is found in south-eastern Ontario. Already two plants have been erected to extract corundum from these rocks, and there is room for others. One of these plants which is just completed is surpassed in size in comparatively few districts in which concentration is being carried on.

Formerly it was the custom to use the lathe almost exclusively in shaping up and reducing the parts of machinery and other metallic articles. The lathe is now being replaced by wheels of abrasive material, which do the work more cheaply and accurately. In working the harder metals and alloys corundum has been proved to have no equal, either among minerals or artificial abrasive materials. Hence it is natural to conclude, when we consider the development already done and the numerous deposits still lying dormant, that Ontario has very valuable assets in this abrasive substance.

3. Refractory materials.

Possessing the wealth in water powers that we do, it is fortunate that there are found in the province large deposits of graphite or plumbago, a mineral which is of great importance as a furnace lining. Deposits of this substance are known to occur in several localities. Two are being worked and others have had preliminary tests made on them recently. Soapstone and other substances used to withstand heat are also to be found. Ontario's graphite exhibit was one of the striking features in the mines building at the Buffalo exposition.

4. Minerals used as pigments.

Pigments or paint materials are produced from a number of minerals, some of which, lead and zinc, have already been mentioned. Our cobalt deposits, however, promise to give us the highest standing as producers of material, metallic, used for coloring purposes. The ore bodies recently found in the vicinity of Haileybury contain ore running as high as 16 per cent. in cobalt.

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The present supply of the metal comes chiefly from New Caledonia, and the ore as mined there does not run a quarter of this percentage. Other mineral pigments occur in the province, but do not need special mention.

5. Gem stones.

Stones of this class have not been found in the province, although the opaque variety of the ruby and sapphire, corundum, as already shown, is abundant. Common beryls are also found, but, as yet, not the gem varieties, emerald and aqua marine. Several minerals which, when cut and polished, have a handsome appearance have been used to some extent. Several writers have drawn attention to the fact that diamonds likely occur in our northern districts. Judging from the fact that these stones are found in drift deposits to the south of the international boundary, and that carbon, e.g., the Sudbury coal and graphite elsewhere, is found in close association with basic eruptives, there seems to be good reason to believe that diamonds may yet be discovered in northern Ontario.

6. Minerals used in certain chemical manufactures.

Probably no chemical manufacture is more important than that of sulphuric acid. There are two working iron pyrites mines in Hastings county. These mines are on deposits which have been known for years, but lay dormant till recently. The mineral is found in promising amounts in many other localities. The great length of our iron-bearing ranges has been mentioned. Belts of rock carrying iron pyrites run parallel to these and appear to carry pyrites in important amounts. Near the Helen mine a large deposit of pyrites has been tested by the diamond drill. Some hundreds of miles to the north-westward a pyrite deposit, situated near an iron claim on Steep Rock Lake, has also been drilled into. Pyrite is found in considerable abundance near Lake Temagami. Mr. Sjöstedt, in a paper read at this meeting, describes a method of manufacturing sulphuric acid from pyrrhotite, our deposits of which are of large size and numerous.

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Molybdenum and other minerals which have been mentioned come under this heading to some extent, as they are used in chemicals.

7. Minerals used in agriculture.

Our phosphate deposits, which are found over a large area in south-eastern Ontario, have lain idle since the discovery of the lower grade, but more cheaply worked, deposits of the southern states. A large supply of gypsum, another mineral of value to the agriculturist, is found in abundance along the Grand River in older Ontario, and on the banks of the Moose, in the north, the substance appears to occur in considerable quantity.

8. Fuels and illuminating materials.

For years past the south-western peninsula of Ontario has been an important producer of petroleum. During the last two or three years the supply has declined. That this part of the province still has important deposits of oil admits of little doubt. Heretofore this substance has been looked for practically only in the Corniferous formation, in which the first wells drilled happened to occur. Within two or three months oil has been struck in promising quantities in two other formations, which up to the present have received little attention from those interested in the industry. One of these formations lies 700 or 800 feet below the horizon from which oil is now obtained, and the other is still older.

In that great, practically unexplored, region of the province which occupies the James Bay slope, the Corniferous rocks are said by Dr. Robert Bell to occupy a greater extent of territory than is embraced in the whole of the south-western peninsula of Ontario. Is it not more than likely that both oil and gas will be found in this northern region when it is rendered accessible by the building of railways? Niagara and other formations also occur there. In fact it presents practically the same geological conditions, but on a larger scale, as the older part of the province which has already proved to be productive.

New gas pools have been exploited recently, and what has been said concerning oil applies to this very useful substance.

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After years of experimenting, the problem of briquetting peat in a form suitable for our market seems to have been solved. If this is the case the numerous large deposits of this fuel in older Ontario will add very materially to our annual income. When the more northern territory is opened up deposits enormous in extent will be rendered available.

It will be admitted, I think, from what I have said that the province has very large undeveloped resources in these three important substances.

9. Materials for brick, pottery and glass.

Materials suitable for brick making are found in abundance in older Ontario, and beyond the height of land, in the great clay belt of 16,000,000 acres, brick should be a very popular material in the settlements that are to come.

The pottery industry is only in its infancy in Canada, and there is likelihood of great development. Feldspar is a mineral which is in great demand for use in the manufacture of pottery. During the last three or four years one of the largest known deposits of feldspar has been opened up in Frontenac county. The quality is such that it is in much demand in the United States. It may be added that feldspar, of which there are many promising undeveloped deposits in the province, is one of those minerals which are found in the formerly much despised Laurentian.

Our glass industry is in much the same position as that of pottery. Even the common raw materials, such as lime and quartz sand, have always been imported for use in our only two working factories, although raw materials of the right quality are to be found here.

10. Cement.

The Portland or artificial cement industry has made rapid strides in this province within the last decade, and there now seems to be little need of drawing on foreign supplies of this material. All of our working cement factories use marl as the raw material for the lime in their mixtures, although a high percentage of the factories in New York State and elsewhere employ solid

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limestone, which it is said makes a saving in the cost of manufacture. It apparently was not known that Ontario had limestone in abundance pure enough for use in cement. One of the factories now being erected is to use limestone. The northern unsettled agricultural region tributary to James Bay is well supplied with this raw material required in the cement industry.

Cement is affecting some of the older industries and trade in some materials is now in a transition state. Cut stone for use in canal work and other structures is being largely replaced by concrete. Lime for use as a mortar is of less importance than formerly. Portland cement is taking its place, especially in buildings which are erected in frosty weather. It is said that in Germany Portland cement has entirely replaced natural rock cement, and it is probable that the same thing will occur here. Cement blocks, when further improved, will also affect the brick industry.

11. Stone.

The stone industry of the province is in what may be called a pioneer state. We import all our granite for monumental and most other purposes, although there is probably no country which possesses a greater variety of granite, either as to size of grain, color or other qualities, than Ontario. Trade prejudices are to some extent responsible for this. Scotland has for years been an important producer of granite for monumental purposes, and it has been the ambition of most Scotchmen to be buried under an Aberdeen stone. Of late years the Scottish granite has met competition in New Brunswick and elsewhere, but the stone is probably passed off as the Aberdeen, and many a son of old Scotia sleeps his long sleep as peacefully under one of these as if it were the genuine.

Marble stands in about the same category as granite. Trade prejudices and the competition of large foreign quarries have prevented the development of the numerous and varied resources in this material which are to be found in eastern Ontario. Attempts have been made to work marble at a number of points in the province, but the works have never got down to depths sufficient to be below the influence of surface agencies, and the quarries

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have been given up practically untested. Renfrew is the only locality which produces marble at the present time. Some wealthy and patriotic citizen of Toronto or of some other of our cities would be doing a good service to the country if he would erect a residence of marble, and thus show that we have material as good as is to be found elsewhere. There is a marble residence in Brockville, but the material was brought from New York State. Marble should also be used in some of our public buildings. What an advertisement it would be if considerable marble had been used in the Science building now being erected in this city! How long, having the resources we do, shall we continue to import our marble from Maine, Georgia and other states?

Jasper, agates, porphyries and other rocks and minerals used for decorative purposes are found in considerable variety here, but little use is made of them. The tourist on Lake Superior who buys a polished agate, for the reason that it is said to be found on the shores of that inland sea, and he desires it as a memento of his trip, often "gets taken in." Most of these agates originate in South America. They are taken to Germany, where they are polished and stained, and shipped abroad to be sold to gullible tourists. These agates are about on a par with specimens that formerly were sold to tourists at Niagara Falls. The hawkers used to solemnly affirm that the rock represented the solidified foam which gathers at the base of the Falls.

Limestones enter into probably more industries than do any other rock or mineral. The uses to which they or their constituents are put are almost innumerable, and the varieties of these rocks which are required by one industry or another are numerous. The older part of Ontario contains limestones adapted to use in any industry. We have those which are practically pure calcium carbonate. These are found among the rocks of the Laurentian series, the Grenville, and in the Cambro-Silurian, the Chazy, Bird's Eye and Black River, and Trenton, being normally of this character as are those of the Devonian, the Corniferous and Hamilton, and recent marls. While others of the Grenville series and of the Upper Silurian system—the Clinton, Niagara, Guelph

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and Onondaga—contain magnesia in varying percentages up to the highest amount possible for a limestone, as distinguished from magnesite.

Limestones carrying a high percentage of calcium carbonate are a necessity in an important group of industries which have already been started in the province, and are sure to reach large dimensions in the future. Having no domestic coal, some of our metallurgical industries, especially in the north, will be dependent to a considerable extent on charcoal, in the manufacture of an important by-product of which a pure limestone is a necessity. In beet sugar manufacture pure lime is also an essential. Portland cement manufacture requires limestone free from magnesia and certain impurities. In the manufacture of calcium carbide, an industry which is peculiarly adapted to this country, and as a flux for furnaces, a pure limestone is also desirable. In the manufacture of sulphite pulp, on the other hand, a rock as high in magnesia as it is possible to obtain it is the most suitable. The fact that such rock is to be found here is important when we consider the field there is for the manufacture of pulp in the province.

In many other industries lime or limestone is essential, and our supply of this rock, of all kinds, is of greater economic importance than most people probably realize

CONCLUSION.

That we should be optimistic of the future is shown by what has been accomplished in the mineral industry during the last decade. I shall conclude this paper by giving a comparative table, which speaks for itself, of our mineral production ten years ago and at the present time.

ONTARIO'S MINERAL PRODUCTION.

A RECORD OF TEN YEARS.

	1893	1903
Iron Ore	None	$ 450,099
Pig Iron	do	1,491,696
Steel	do	304,580
Corundum	do	87,600

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	1893	1903
Arsenic	None	$ 15,420
Feldspar	do	20,046
Iron Pyrites	do	21,693
Graphite	do	20,636
Zinc Ore	do	17,000
Pig Lead	do	1,500
Talc	do	2,625
Molybdenite	do	1,275
Calcium Carbide	do	144,000
Nickel	454,702	2,499,068
Copper	115,200	716,726
Gold	32,960	188,036
Silver	2,500	8,949
Bricks, etc.	1,684,873	2,612,509
Stones, etc.	721,000	845,000
Rock Cement	63,567	69,319
Portland Cement	63,848	1,182,799
Gypsum	7,363	7,910
Lime	364,000	520,000
Mica	8,600	102,205
Natural Gas	238,200	196,535
Petroleum, etc.	2,188,690	1,586,674
Salt	149,850	388,097
Unclassified, etc.	9,600	4,950
Total	$6,105,953	$13,306,947

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

MR. GIBSON—I cannot add much to the comprehensive statement which Professor Miller has made as to the undeveloped resources of our province. There is no doubt that in the newer and almost unprospected regions lying to the north, both on this side and on the other of the Height of Land, there are many areas underlaid by mineral bearing rocks which are waiting the prospector, and where in the future we may expect to find large deposits of valuable minerals of various kinds. In the older portions of the province, which have long been used for agricultural purposes, there are undeveloped resources which will yet prove of great value. I cannot but think that we have yet undiscovered reservoirs of petroleum and natural gas in the rocks far beneath those from which our present supplies are obtained, and indeed

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as Professor Miller has remarked, we have proof of that of very recent date. I had the pleasure of seeing some petroleum taken from one of the formations underlying the Corniferous not longer than a week or ten days ago, and from a formation which has not heretofore yielded petroleum in commercial quantities in this province. I would like to add one remark in regard to a non-metallic substance which I think is likely to be of great importance. We are situated in a coalless country. I mean that in the older portions of Ontario we can never hope to find coal seams of value. What there may be north of the Height of Land in the shape of deposits of lignite is another story, and I believe we have lignite bodies there that will yet be of economic value. But in the peat bogs of this province there are large stores of carbon which will undoubtedly yet be used for domestic and other purposes. The problem of manufacturing a satisfactory peat fuel from the bogs of Ontario is one which has presented no small difficulty. The main difficulty is the economical extraction of the water, which the peat fibre so tenaciously retains. That has been the stumbling block in the many attempts which have been made to manufacture a satisfactory fuel from the peat bogs, not only of this country but of other countries. However, there are very few difficulties in this matter, as in almost any other, which the ingenuity of man will not overcome when seriously exerted. I believe that peat processes have been perfected which now give satisfactory results. At any rate that applies to certain kinds of bogs, and as the proof of the pudding is in the eating of it, I want to tell my experience. When I learned that briquetted peat fuel was being manufactured and sold, I determined to make a trial of it in my own house, so I laid in a considerable supply last fall, and have been burning it in the kitchen range for the greater part of this winter. I can assure you, Mr. President, that it has given to myself and the inmates of my household the greatest satisfaction. Not only does the fuel give a strong steady fire, but it makes little dirt, is easy to handle and is almost absolutely certain of prompt ignition; in this respect being better than wood, and better also than anthracite. Some people are using this fuel in their furnaces. I did not use it much in the heating furnace,

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but I know that if your fire in the furnace becomes low and sluggish, and you throw a shovelful of peat upon it and cover it with anthracite, in five minutes the coal is glowing hot. My observation is that peat is best adapted for the kitchen range, and is as good a fuel as we know of for domestic purposes, with the possible exception of gas. You cannot alter the nature of a bog after it has been formed, and if you get a fuel that is high in ash there is a good deal of waste; unfortunately that has been the case with some of the peat bogs that have been experimented upon in the past. Another difficulty is that our present furnaces have not been adapted to the burning of peat, and consequently there is a considerable loss on account of the unconsumed particles falling through the grate. I am in hopes that in the peat bogs of Ontario and Quebec and other portions of Canada, we have what will yet be a most important asset. Instead of our looking upon these bogs as being waste, as we do to-day, I believe we will yet come to regard them as a valuable portion of the country's natural resources.

DR. BELL—Notwithstanding the new views put forward by some, I am far from being converted to the theory that petroleum is of volcanic origin. As to our petroleum field in southwestern Ontario, from the first time I looked into this matter I did not consider it certain that petroleum originated in the Corniferous limestone. In 1887 I wrote a paper on the subject and presented it to the Royal Society of Canada, in which I set forth very distinctly the idea that the petroleum might not originate in this formation, but probably came up from the Trenton limestone far below; that there is some natural way in which it comes up, probably by numerous fissures filled with water, and that we have a comparatively inexhaustible supply of petroleum in this formation. We have pumped our Ontario petroleum fields for forty years, and we have taken out more petroleum than would form the whole bulk of the Corniferous limestone in the area worked. If it comes up from a great depth, from the Trenton below, there is hope that not only more petroleum will be obtained there, but that new fields will be found in this province, where the Trenton limestones occur under the other formations, and where a low

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anticlinal or dome structure exists, together with other necessary conditions, such as impervious strata to hold down the oil.

PROF. MONTGOMERY—The people of this province are taking a great interest in our mineral development, which affords so much hope for the future. We are all very glad to know from the Provincial Geologist that there is so much ground for hope that there will be very important mineral development in Ontario in the future. Our disappointment in the past has been probably caused by other reasons than the absence of good mineral ore. It is some years since I was present at a meeting of the Institute and I notice many changes, the greatest one being the absence of our friend Mr. Bell. I would like to ask if there has been similar work done upon the pyrrhotite of other localities in Pennsylvania, California and elsewhere, as compared with British Columbia and Ontario. I would like also to know with regard to our zinc, the mode of occurrences and the reduction of this zinc ore in Ontario as compared with the zinc ores of Missouri and other places. I thought I might ask also whether there is sapphire in the deposits at Peterborough and Hastings. I collected several very pretty specimens of blue corundum in Methuen township, county of Peterborough, in 1897 and 1898, but I could scarcely regard them as true sapphires. Some eight years ago I found uraninite in Quebec not far from the Ottawa River, and I presume it may have been found in Ontario localities. I should like to get more information about the celestite near Marmora, and about the idocrases and zircous near the Ottawa.

We are all much indebted to Prof. Miller for the splendid paper he has given us and the trouble he has taken to present it to this Institute.

DR. ADAMS—In the presence of so many eminent authorities on the mineralogy of Ontario, I feel that I am unwise in accepting the chairman's invitation to speak. I may say, however, that there are very large deposits of pyrrhotite in the townships of Galway and Somerville, which we found in making the geological survey of that district and which have so far been considered of little value on account of the fact that it has been impossible to obtain sulphur from them. If they could be worked on an economic

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basis there should be large supplies of sulphur in that district. In our work in Eastern Ontario, Dr. Barlow and I have succeeded in finding in the Laurentian limestones of this part of the province within two of the total number of minerals that have hitherto been found in the limstones of this age on the whole continent. It is true that most of these are not of economic value, but the fact shows how rich Ontario is in minerals and the importance of the services which Professor Miller is rendering to the province. The province of Ontario was placed in very good hands when its interests were confided to Professor Miller, who will ably guide it in the systematic exploration of its valuable resources. I congratulate the province of Ontario in having secured the services of Professor Miller.

DR. BARLOW—No deposit of hematite of economic importance has yet been located in connection with the Temagami iron range. Two of these however have been accurately outlined and during the coming summer Canadian capital will be used in prospecting for the large secondary deposits of hematite which it is hoped will be found. The geological horizon of these iron ranges is the same as the famous Vermilion iron range of Minnesota.

THE PRESIDENT—An important point has been brought out by Professor Miller, and that is that the Laurentian was not to be despised as bearing minerals of economic value, and was in that respect perhaps as valuable as the Huronian.

As regards the future prospects in the province of Ontario for new oil and gas fields, I have no hesitation in saying that they are very bright along certain faulted and fissured belts or zones in the province. Along these belts many porous rocks of the sedimentary strata (sandstone, limestone, etc.) will be found impregnated and filled in places with these valuable products which are volcanic emanations from below. Not only the Corniferous, but the Hamilton, the Onondaga, the Guelph, the Niagara, the Clinton, the Medina and the Trenton are already and will be productive in many fields in the province.

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Journal of the Canadian Mining Institute, Vol. VII.

A NEW AREA OF COPPER-BEARING ROCKS IN THE EASTERN TOWNSHIPS OF THE PROVINCE OF QUEBEC.

By John A. Dresser, M.A., Montreal, Que.

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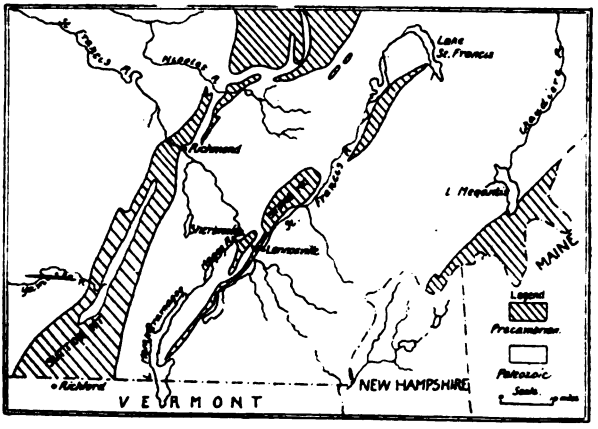
Toronto Meeting, March, 1904.

On the latest map of the Eastern Townships issued by the Geological Survey, three areas of Precambrian rocks are indicated. They form nearly parallel belts, which run to a northeast and southwest direction, generally from twenty to thirty miles apart, and are themselves from two to fifteen miles in width. They usually form conspicuous ridges which are frequently the highest hills of the district. The intervening areas are occupied by later sediments. The extent and relative position of a part of these belts is shown by the accompanying sketch map (vide American Journal of Science, Vol. XIV., p. 43).



Part of the Eastern Townships of the Province of Quebec.

The western and central belts have long been known to be copper-bearing. They have yielded all the copper yet produced

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in the Eastern Townships, with the exception of that from the Acton and the Huntingdon mines and the minor properties in the vicinity each of these widely different deposits.

In a communication to this Institute in 1902, the writer pointed out that the greater part of these two belts are of volcanic, not sedimentary, origin, as had been previously believed. The view was also then advanced that all of the copper locations of the district of any known, or probable, importance would be found to occur in the igneous portions of these belts, and that those reported from the sedimentary parts of the Precambrian were likely to be of insignificant value. This view has been fully sustained by the results of two seasons' field work in this region, which have since been carried on for the Geological Survey.

Of the third Precambrian area, that around Lake Megantic, little is yet known. The wooded condition of the country along the boundary of the state of Maine, at the time that the south-eastern quarter sheet of the Eastern Townships map was prepared (1885-6), prevented a detailed examination of the area. Yet the rocks were correctly correlated with the others in the townships already referred to the Precambrian systems. (Report of the Geological Survey, 1886, J., Dr. R. W. Ells.)

In the summer of 1902 the writer spent a few days in an examination of the rocks in the vicinity of Lake Megantic. Outcrops were examined and specimens taken for forty miles along the western edge of the Precambrian area, and in a southerly course across it from Lake Megantic to the Arnold River, near the Maine boundary. The greater part of the rocks thus seen were found to be of volcanic character, like those of the Sutton and Stoke belts. In a cutting twenty rods in length on the Canadian Pacific Railway, near Boundary Siding, the rock, which is quite similar to the copper-bearing rock of Ascot, is everywhere rusted by the oxidation of pyrites. In the central part of this cutting copper and iron pyrites comprise from five to ten per cent. of the rock, through a band upwards of ten yards in width. Copper is reported to occur in the bank of the Arnold River south of the village Channay, between Lake Megantic and the boundary line

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of the state of Maine. Owing to high water at the time of my visit I did not go to the locality.

Topographically considered, this area seems to be a northern extension of the copper-bearing range of the vicinity of Berlin Falls, and Copperville, in New Hampshire.

Dr. Chalmers reports the rocks of Ditton, in the southern part of the eastern Precambrian area, to be similar to those of Stoke Mountain. The latter are volcanics. The two areas, Ditton and Dudswell (which latter is in the southern part of Stoke Mountain) are further alike in that the gravels of both carry considerable amounts of placer gold. In Dudswell the volcanic rock is evidently the source of the gold, while in Ditton Dr. Chalmers also considers the gold to have been derived from the rock of the adjacent hills. Hence the occurrence of gold in the rocks farther to the eastward, along the tributaries of the Chaudière, which has been reported by Logan, Michel, Selwyn and Chalmers, is a probable indication of the continuance of the copper-bearing volcanics in that vicinity.

Further to the eastward, in the highlands of Gaspé, several observers, notably Logan, Ells and Low, have reported the occurrence of rocks characterized by chlorite and epidote, but no detailed microscopic study of them has yet been made. They are presumably a continuation, or recurrence, of this class of copper-bearing traps. Hence it seems probable that the watershed which determines the boundary between the Province of Quebec and the state of Maine, will, as the country becomes accessible for detailed examination, be found to be a continuous ridge, or succession of ridges, of copper-bearing volcanic rocks, which may ultimately be connected with the cupriferous Precambrian of New Brunswick.

In view of the prospective opening of the eastern extension of this district by the projected Grand Trunk Pacific Railway, the actual extent of these rocks is likely to be soon known, and the value of the deposits they may contain becomes a problem of early importance.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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DISCUSSION.

MAJOR LECKIE—Mr. Dresser has been good enough to mention my name in connection with the copper deposits of the eastern townships, and I thank him for it. I am possibly the oldest engineer now in Canada, who has had experience in these deposits, with the exception of Dr. Douglas, late President of the American Institute of Mining Engineers. Forty odd years ago I opened up these mines at Capelton, and I may say that the Eustis mine which we opened up about 1880 is now down fully 3,000 feet. The body of ore will run from 6 or 7 feet up to 40 feet. It is a lense shaped mass; nearer the surface it carries about 4 per cent. of copper and an ounce of silver to the unit of copper, per ton of ore. Now the copper has got a little reduced, and will average about 3 per cent. and 3 ounces silver. But the sulphur has increased and is now about 45 per cent., which makes it a very valuable ore for the production of sulphuric acid.

THE PRESIDENT—Major Leckie has told us that he is the oldest engineer in the room, but to look at him no one would believe it.

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Journal of the Canadian Mining Institute, Vol. VII.

ON THE NICKEL DEPOSITS OF NORWAY.

By Major R. G. Leckie, M.E., Sudbury, Ont.

Toronto Meeting, March, 1904.

The similarity of the older geological formations of Norway to those of Canada, was pointed out by Mr. Thomas Macfarlane, F.R.C.S., forty years ago, in a series of papers published in the *Canadian Naturalist.*

The west coast of Norway is occupied by the Archean or Primitive, as it is there called, the equivalent of our Laurentian. Gneiss and granitic-gneiss are the prevailing rocks, the others occurring only subordinately. The serpentine (or ophiolites, as they are described by Dr. Sterry Hunt) of the Laurentian, like that of the Norwegian Primitive, carries no nickel, differing in this from the serpentine and peridotites of the Silurian. A peculiar series of Archean rocks, called the Telemarken is described by the Norwegian Geological Survey as "obviously clastic," such as conglomerates, sandstones and clay slates, but besides these rocks crystalline schists, gneisses, granulites and hornblende schists also occur. The strata are folded and often traversed by granite dykes. The students of ore deposits have been puzzled over the nature of these. The veins are described as true fissure veins cutting the vertical strata at an acute angle. These are silver-bearing, filled chiefly with calcite. The silver occurs only where the veins intersect the pyrites-bearing bands of the country rock. These are the Fahlbands described by Mr. Macfarlane.

The celebrated Kongsberg "The King's Mountain" mine occurs on one of these series of fissure veins. It has been worked for over 250 years and yielded, in that time, 898 tons of fine silver, but the great fall in the value of silver has rendered operations in recent years quite unprofitable.

It is in the pre-cambrian and Cambro-Silurian that the deposits of copper, nickel and cobalt occur. The copper mines

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of Roros were started in 1646, and are today more largely operated than ever. The ore averages 5 per cent. copper, is smelted in water-jacketed furnaces, the matte bessemerised and brought up to 99.50 per cent. This is refined. The works are up to date.

The Sulitjelma copper mines in Saltem are of more recent opening, having been first worked in 1887. At present 30,000 tons pyrites are exported and 450 tons of refined copper produced at the works yearly.

The island of Ostero is the largest on the west coast of Norway and is situated about eighteen miles north of Bergen. It is embraced in the great development of the Archean rocks, which stretch along the coast from Bergen on the south to Hammerfest in the north.

Several ridges, rising occasionally to a height of 1,500 feet, traverse the island from east to west. These are composed of syenite, mica schist, hornblende schist, gabbro and diorites. Over a length of five miles, interbedded masses and lenses of pyrrhotite are found running subordinate to the stratification.

At Fieldskuldnaes, near the shore, three promising outcrops of ore occur, but no development work has been done other than removing the overlying soil. Continuing eastward on the strike, considerable development work has been done, in the beautiful little valley of Littland.

A shaft has been sunk 100 feet on the dip of the vein and also two trial pits, one to the east and one to the west, proving the continuity of the ore for a length of 800 feet. Here it has a width of from six to nine feet and a dip of from 15 degrees to 20 degrees. The pyrrhotite is not compact, but mixed with hornblende, feldspar and quartz. The ore pile at the shaft assayed 2.35 per cent. nickel and 1.02 per cent. copper. From the level of the little lake an adit level could be driven in which would facilitate drainage and give a good back of ore when driven towards the rising ground.

About 600 yards north on the shore of the lake another vein is seen, but under water. The width appears to be about 7 feet of compact pyrite and pyrrhotite.

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Ascending the ridge and at a height of 800 feet above the sea level, No. 4 mine of the Noonas group is reached; then the continuation up to Nos. 2 and 3. Here the ore bodies are more broken and dip at an easy angle, from 10 degrees to 15 degrees. The ore in places is compact, of a bronze-yellow color, and at other points is scattered through the underlying diorite. Samples from piles ready for shipment yielded: from Number 2, 2.15 per cent. nickel and 1.21 per cent. copper; from Number 3, nickel 1.85 per cent., copper 1.95 per cent., showing that there was a considerable proportion of earthy gangue present.

Number 1 workings are at an elevation of 1,050 feet above sea level. The ore-bodies are irregular and detached. The north or hanging wall side is largely composed of hornblende schist and mica schist, the underlying or foot wall side showing more gabbro. Some copper ore of good grade, running over 7 per cent. was shipped from here, but the nickel contents were low. The average of the shipments from this point, however, ran about 2 per cent. copper and 2 per cent. nickel.

A good waggon road from the wharf to the highest working has been built, while the ore from Numbers 2, 3 and 4 was conveyed by wire cable to the shipping point, a distance of 1,500 yards. The deposits at Littland and Fieldskulnaes are still more convenient to the wharf, where vessels of the very largest tonnage can lie in perfect safety in the well protected fiord of Lonevaag.

South of Bergen about ninety miles, and about seven miles out from the harbor of Haugesund, lies the island of Foeoe. It forms one of the interesting group, which protects seaward the entrance to Haugesund.

These islands are composed of granites, syenites, quartzites and schists. A deposit of compact sulphides has been opened up on the island of Foeoe and about 4,000 tons of ore shipped. A vertical shaft has been sunk to a depth of 120 feet and levels extended east and west for a total distance of over 300 feet; a winze has been put down, near the face of the east level, to a depth of 20 feet; these workings have been in ore all the way. The ore-

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body strikes east and west and dips at an angle of about 45 degrees south. Its thickness is irregular, running from four feet up to sixteen feet and lies conformable to the stratifications. It has the appearance of three lenses, whose ends slightly overlap and their continuation in depth has not yet been determined. The country rock is rather fine grained gabbro, with narrow bands of hornblende schist interstratified on the north side.

The ore is hard and free from gangue. About 600 tons selected for copper were shipped to England and yielded 8.50 per cent. copper. Two cargoes of run-of-mine were shipped to New York and assayed 2.25 per cent. nickel and 2.25 per cent. copper.

The shaft is situated within 40 yards of the loading chute, underneath which vessels of 5,000 tons can load in any weather, as the cove is perfectly land locked. The facilities for shipping could not be excelled.

In the southern part of Norway the important nickel mines which have been opened are those of Evje, Ringerike and Askim.

The Evje mines are situated on the mountain range which forms the eastern boundary of the Otter Valley, at an elevation of 500 feet above the river. The geological formation is very similar to that described at Ostero and Foeoe. The schists are tilted to a high angle and by contraction or lateral pressure have become corrugated, these corrugations running at right angles to the strike. The openings produced in the foliation, have become filled with iron sulphides carrying nickel and copper, but sometimes a pinkish colored feldspar occupies the full width of the opening. Occasionally fine crystals of tourmaline are found in it. These ore deposits form, therefore, a series of lenses, more or less connected, or they may be described as a saddle reef, only instead of following each other vertically, as in the gold-fields, they form a series of saddles in horizontal series, somewhat flattened, so that the flaps touch each other. These may be described as the leaders, which guide the miner in following up the series of ore deposits.

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The ore is of good grade according to many analyses made by Messrs. H. H. Vivian & Company, who worked the mine for some years; the average runs from 3.30 per cent. nickel to 4.05 per cent. and 1.00 to 1.30 per cent. copper. Cobalt is always present, some assays showing as high as 0.50 per cent.

This ore is carted down hill about three miles to the river bank, where it is put on the roast beds and calcined. Care is taken to retain what we should consider a high proportion of sulphur, the object being to produce a matte from first smelting carrying 12 per cent. nickel and 4 per cent. copper. The loss in slags being kept down to .20 per cent. The matte is taken to the open hearth, where it is brought forward to a matte carrying 65 per cent. to 70 per cent. of the combined metals. An average analysis is given as nickel and cobalt 50.90 per cent., copper 17.00 per cent., iron 9.30 per cent, and sulphur 22.80 per cent.

The main shaft has reached a depth of 91 meters (290 feet). On the west side a face of good ore is exposed. On the 80 metre level a body of ore 16 feet wide by 13 feet high was being stoped; length undetermined.

Pumping and hoisting are effected by turbine, driven by a sixty foot fall of water, on the Odde River; the power being conveyed by wire rope. The works are situated near the falls of the Odde River, which furnishes power for all the machinery required. If this power were developed, it should be equal to 2,500 horse power. No mining location can surpass this for facility of cheap development. The ground is favorable for an adit level, which would give a back of 500 feet on angle of dip. The power for air-compressors, electric motors, etc., would be furnished by water power on the spot.

The mining district of Ringerike is one of the most beautiful in Norway. The Tyrifjord, with its surrounding mountains and numerous fertile valleys watered by clear mountain streams, reminds one of the impressive scenery of the eastern townships.

The railway runs up the charming valley of the Drammen to the Randsfjord and other great lakes stretching down from the

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north. The mines of Ertelien, Langedal and Stoverntangen have furnished the smelting works at Vaeleren with over 50,000 tons of ore. The cost of this delivered was about $1.75 per metric ton. The average contents was 2.10 per cent. nickel, 1.00 per cent. copper. Cobalt was usually present to the amount of 0.20 per cent.

Mr. Macfarlane, who spent several years in that district of Norway, says: "The fahlbands in the neighborhood of Ertelien and Ringerike have not been so carefully studied as those of Kongsberg and Skuterud, nevertheless it admits of no doubt that the nickel mines of the former locality occur on impregnated zones of rock like the fahlbands. The deposits are irregular masses of magnetic iron pyrites containing 2 per cent. metallic nickel. Although a definite veinstone is not observable, it appears from the presence of salvages in various places, that the deposits partake of the nature of veins." From personal observation I am disposed to agree with this description, as the conditions under which these ore deposits occur, are different from those already described.

The ore is found interlaminated with the schist and two tons have to be broken to furnish one ton of smelting ore. These schists dip at a high angle and are cut in two places by diorite dykes. The surface workings extend over a length of half a mile. The ore is conveyed to the smelting works by wire tramway and is treated in the same manner as that at Evje.

At the smelting works the plant is driven most of the year by water power. There is an abundance of wood on the company's estate both for mines and fuel as well as for building timber. Coke brought by rail from Drammen costs $5.00 a ton and labor is abundant and cheap. The manager estimates that he could deliver 50,000 tons a year, to a smelting works.

The cobalt mines at Skuterud, of which Mr. Macfarlane was for several years manager, are described by him as occurring "on a fahlband which has been traced about five miles, the rock being quartzose mica schist. Layers of impregnated hornblende and actinolite schist are also of frequent occurrence. The rocks run north

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and south, and have a dip nearly vertical; sometimes inclined slightly to the east, sometimes to the west. In these rocks the following metallic minerals have been observed: magnetic iron and copper pyrites characterizing the fahlband; cobalt glance; cobaltine; cobaltiferrous-mispickel; magnetic iron ore; graphite and molybdenite are found more sparingly, impregnating the fahlband at certain places. They seem to form a succession of small layers running parallel with the foliation of the rock. The fahlband itself has a breadth of from one to five fathoms."

These ores were crushed in a stamp mill and concentrated on percussion tables. The concentrated ore was roasted and smelted in reverberatory furnaces. The matte or Zaffre, containing about 30 per cent. cobalt oxide, was shipped to England, where it was manufactured into pure cobalt oxide and smalt.

The nickel mines of Askim are thirty-three miles by rail from Christiana and forty-one miles distant from the port of Fredrikstad, with which they are connected by railway.

The low mountain ridge of Romsaas rises out of a very fertile valley, to a height of 250 feet. The country rock is here similar to that of Ringerike, but is more broken and disturbed with diorite dykes. The ore occurs in detached masses having a length varying from 30 to 60 feet, with an average thickness of six feet. Occasionally the vein or fissure is filled with feldspar and a little hypersthene. About 30,000 tons have been mined, one-half of which was picked out by hand for the smelting works. The average of this was 2.40 per cent. nickel and cobalt. Some of the ore was roasted and other lots smelted raw, so that the first matte was low grade and irregular, running from 5 per cent. to 7 per cent. This was roasted and subjected to another smelting which brought the nickel contents up to 35 per cent. No attempt at systematic development of the deposit has been made, although the location offers every facility for so doing. An adit level can be brought in from the low valley and the whole mineral zone cross-cut.

This mineralized zone has a length of 350 yards and a width of 100 yards. A large concentrating plant would be required and it is very doubtful if this could be made to pay at present prices

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of nickel and cobalt. The concentrates do not carry over 3.50 per cent. to 4.00 per cent. nickel and cobalt with about 0.50 per cent. copper.

The Glommen River, the largest in Norway, tumbles over immense falls, within 1,500 yards of the mine. A company has just completed a plant which develops 45,000 horse power, and is prepared to furnish electric current at the rate of $15.00 per horse power per annum.

It will be seen by the foregoing that although there are in Norway many extensive bodies of pyrrhotite carrying nickel and cobalt, yet they are too scattered and too low grade to successfully compete with the great mines of New Caledonia and Canada, under present conditions. The particularly favorable position of Ostero and Foeoe for shipping ore to foreign markets or for the importation of fuel, might enable them to be worked on a moderate scale.

The owners are hopefully waiting for the enforcement of the export duty on Canadian ore and matte, which they believe will again give Norway a large share of the European nickel market.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

MAJOR LECKIE—In this paper, as in the one I read a year ago, I have endeavored to show in some manner the analogy between the rocks of these foreign countries, where I have examined nickel and copper mines, and those of Canada, so that my notes may be in some measure of advantage to the prospector in Canada.

THE PRESIDENT—On behalf of the Institute I thank Major Leckie for his valuable paper, which is interesting in describing the deposits of Norway in comparison with the deposits of Sudbury and other parts of Canada. We are fortunate in having as a member of this Institute, Major Leckie, who has had experience not only in Canada but in many other parts of the world.

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MR. OBALSKI—Major Leckie has much experience in the eastern townships, and I would like to ask him how the Norwegian field compares with the eastern townships.

MAJOR LECKIE—The deposits of nickel in Norway resemble more the deposits in our Huronian, but those of the eastern townships are Silurian, and of the same age probably as those of New Caledonia. Dr. Sterry Hunt did more original work in his day in regard to these serpentines than any other man. I love to bring up his name before this Institute because he has rendered such valuable services to Canadian geology, both from its scientific and economic aspects. Everyone who refers to the reports of Dr. Sterry Hunt in the sixties will realize that what I say is correct.

MR. STEVENSON BROWN—I was associated with Dr. Sterry Hunt more than thirty years ago in connection with the Natural History Society of Montreal, as well as in the Montreal Microscopical Society; and as Major Leckie has mentioned my name I have pleasure in adding my testimony to the splendid work which Dr. Sterry Hunt has done for Canada and for the advancement of science at large. I can also remember the great interest which Dr. Sterry Hunt took in students' work, and the kind manner in which he was always ready to assist them.

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Journal of the Canadian Mining Institute, Vol. VII.

ON THE OCCURRENCE AND DEVELOPMENT OF CORUNDUM IN ONTARIO.

By M. B. Baker, B.A., B.Sc., Kingston, Ont.

Toronto Meeting, March, 1904.

With the great advances made in the industrial world of late years, the question of abrasives has grown to be one of great importance. A few years ago the difficulty was to produce an abrasive, at a sufficiently low cost, that would be hard enough, enduring enough, and fast enough in its grinding powers to successfully compete with lathes, planes, etc., in iron and steel work. Many abrasives were tried, but all failed in one particular or another. Crushed steel, sand-stones, emery wheels, garnet-stones, and carborundum were all tried in turn, but were not a success entirely. The emery had the largest use, and came nearest to the requirements. The manufacturers saw that the corundum was the valuable part in an emery wheel, but were compelled to use the emery, as a pure or continuous supply of corundum could not be had. It was not a surprise, therefore, that great interest was taken in the reported finds of pure corundum in economic quantities in Ontario.

The discovery of corundum, even in Ontario, was not a new thing, but its discovery in deposits of economic importance was new, for the corundum deposits of North Carolina were not equal to the demand for corundum, and the industrial world had to be satisfied with a first grade of emery stone. It is claimed that India is the original home for corundum, and that the name is a modification of the old sanscrit term Korund. At any rate, India has for a long time been famous for the gem varieties of corundum, e.g., the rubies of Burma, and the sapphires of Cashmir are famous. These precious stones, on account of their brilliancy, naturally attracted the natives, who have always attributed very

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special qualities to these stones, believing that they possessed great medicinal values and powers of magic.

We have, for instance, the following description of corundum by an ancient writer: "This is the gem that feels the influence of the air, and sympathizes with the heavens and does not shine equally if the sky be cloudy or bright. Besides, when put in the mouth, it feels colder than other stones. For engraving upon, indeed, it is by no means adapted, inasmuch as it defies all grinding. It is not, however, altogether invincible, since it has been engraved upon, and cut into shape by means of the diamond. Corundum is used as a medicine, chiefly as a cooling agent in fevers and inflammations, and applied to wounds to stop bleeding, the blue perfect corundum (i.e., sapphire) has the additional power of quenching fire, etc."

Although India is claimed as the home of corundum, it is not by any means the only foreign country producing corundum, for it is now reported from Burma, Russia, Turkey, Greece and the United States.

In this latter country it has been mined chiefly in North Carolina, but the supply is limited and the output of pure corundum was therefore very small, e.g., the total output of the United States for 1897 (e.g., the last year before the finds were reported in Ontario) was only 230 tons.

The result was that when corundum was reported in economic quantities in Ontario, it very soon appealed to the manufacturers and such an interest was aroused in it, that to-day Ontario possesses the largest, purest and practically the only productive deposits of corundum in the world. Even the United States is getting practically its whole supply from Ontario, and a very substantial market is being established in Europe as well.

It has been exceedingly interesting to watch the development of the corundum industry in Ontario during the last five years. The first two years were required for prospecting and examining the belt, and the last three years have been the only ones used in producing the corundum. As mentioned above the output for 1897 in the United States was 230 tons. The first year of Ontario's production was 60 tons, the second year 534 tons, and last

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year the output for Ontario was 1,137 tons. It is doubtful if any other mining industry has developed as rapidly in the first three years of its existence.

The first occurrence of corundum in Ontario, or in Canada for that matter, was reported in Geology of Canada, 1863, where the following reference is made: "Corundum has been observed on the second lot, of the ninth range of Burgess, and in the vicinity of a deposit of copper pyrites. Here, in contact with a crystalline limestone, occurs a rock made up of feldspar, quartz, calcite, silver-white mica and sphene. Disseminated through this rock were small grains of a mineral, whose color varied from light rose red, to sapphire blue, while its hardness, which was greater than that of topaz, showed the mineral to be corundum. Small blue crystals of corundum have been found elsewhere through the limestone of the vicinity." As no specimens from this locality were collected for the Geological Survey at the time, and as no one could be found who had actually seen the occurrence, Prof W. G. Miller—then Professor of Geology at the School of Mining, Kingston—and to whom a great deal of the success of the corundum industry in Ontario is due, undertook to re-examine the district and try to find the mineral again. Accordingly, one of the annual fall excursions, run by the School of Mining for the benefit of the students, was taken up the Rideau Canal, and on the second day of our outing, Prof. Miller located the occurrence mentioned in the Geology of Canada, 1863, and obtained specimens of the crystalline limestone carrying small rosy crystals of what appeared to be corundum. The crystals were very small and Prof Miller was not positive that they were corundum, and made the following foot-note on the occurrence (Rep. Bur. of Mines, 1898, p. 214).

"As, however, the mineral spinel has a hardness equal to that of topaz and occurs in limestone under conditions similiar to corundum, it would seem advisable that a careful examination, chemical and otherwise, be made of these specimens, before their character is affirmed. . . . One specimen obtained had a rather suspicious octahedral character."

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I understand that Prof. Miller has since proven that some of these crystals are spinel, but thinks it likely that both minerals are present as they occur under such similar conditions. This occurrence, then, while of scientific value, was of no value commercially, as no appreciable amount of corundum could be found there.

In the meantime, however, another and more interesting discovery had been made in Hastings County. It came about in a rather unusual and interesting manner, and shows beyond a doubt the advantage that a technically trained man has in the mining world over the crude prospector or even "local geologist" that we find in almost every locality. Mr. W. F. Ferrier, of the Geological Survey, had in 1893 purchased a number of specimens of minerals from Mr. Stewart of Ottawa; among them was a package labelled "Pyroxene crystals from south part of Carlow," Carlow being one of the townships in Hastings County. But on examination of these specimens Mr. Ferrier saw that they were corundum crystals. He communicated the fact to Dr. Dawson—then director of the Geological Survey—who instructed him to proceed to Carlow and try to locate the mineral in place.

After spending some time in Carlow township, Mr. Ferrier landed at "New Carlow" post office, which was kept by Mr. N. T. Armstrong, one of the oldest settlers of Hastings County.

He showed the specimens to Mr. Armstrong, who at once said they came from his own place, and accordingly took Mr. Ferrier to see his "phosphate" mine, thinking the corundum crystals were apatite.

This deposit occurs in a big hill, at one end of which was a cliff about 100 feet high, and in the face of this cliff the corundum crystals could be seen studded thickly in the rock. This deposit is now worked by the Ontario Corundum Co.

The discovery of this corundum, then, in economic deposits, at once attracted attention, and enquiries at once began to be made at the Bureau of Mines concerning the deposits. The Director of the Bureau at once directed Prof. Miller to examine and report on the known occurrences and to endeavor to trace up others.

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The work was, therefore, commenced in June, 1897, and in that and the following year Prof. Miller and his assistants found corundum in more or less quantity along a belt of rocks about 75 miles long and from 2 to 8 miles wide.

In view of the extent and richness of some of the deposits, the government took steps in 1898 to insure the development and exploration of the deposits on a sufficiently large scale to warrant success; they accordingly withdrew all corundum bearing lands from sale or location, and allowed only a leasehold to be granted to responsible companies for the satisfactory working of the deposits.

Tenders were, therefore, called for by the Commissioner of Crown Lands for those privileges up till Sept. 15th, 1898, and a partial agreement was made with Jos. N. Shenstone and Lloyd Harris of the Massey-Harris Co. and B. A. C. Craig of Toronto, that they should explore the corundum belt and select corundum bearing lands from it, not to exceed 2,000 acres; they were to work these, and investigate the industry in many lines for other possible products.

These gentlemen at once engaged Mr. Thomas Hodgson, who had been Prof. Miller's assistant the previous year in the field, and myself, to go carefully over the belt and select the best deposits for working. By September of that year, i.e., 1899, we had selected 1,400 acres of corundum bearing lands for these people. Accordingly these lands were leased on September 15th, 1899, and the Canada Corundum Company was organized to work the deposits.

Up to the present time this company has been working on a very small scale, and chiefly in an experimental way. By remodelling a saw mill and working on a small scale, with many kinds of plant, they have at least practically solved the problem of getting almost pure corundum from the gangue of feldspar, etc., so much so, that they now supply the trade with a 97 per cent. pure Al_2O_3. Having overcome the difficulty of getting a high-grade product this company is now at work in a new large mill with a capacity of 200 tons of corundum rock per day, and the

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chief separation is made on Overstrom and Wilfley tables, the old method of jigs being discarded.

Not to be outdone, the "Ontario Corundum Company" has just started operating a new plant. Their former plant was a small experimental one also; they simply crushed their ore to about egg size and made a rough coarse jig-concentration and shipped the raw material, carrying probably 60 per cent. corundum, to the United States for milling and final separation. Seeing that the freight on the waste gangue was a considerable item, they have now built a mill at their mines here in Ontario, and they also make their separations here now, their capacity being about 100 tons of corundum rock per day.

Thus we see that there are two well established corundum producers in Ontario now, but they are both working on private lands and not on government property, as both these mines are on property deeded over 30 years ago to early settlers, and lands on which there was no reservation of mineral rights.

Believing that there might be other deposits of corundum on government lands in the corundum belt, and not yet taken up, Mr. John Donnelly, M.E., of Kingston, engaged me in the spring of 1901 to go over the belt and search for corundum.

I left for the field in April, accompanied by Mr. A. Longwell as assistant, and after spending six weeks in the field succeeded in finding an excellent deposit on Lots 27 and 28, Con. XIX. of the township of Raglan, in Renfrew County. Having seen practically all the corundum exposures in their undeveloped state so far found, I had no hesitation is saying this was as promising as any, with the possible exception of the Craig Mine. But, on subsequent stripping and opening up, it is doubtful if this new find is second even to that.

The corundum here occurs in a coarse-grained pink syenite, as it does at the Craig mine, and at the Ontario Corundum Company mine. The deposit occupies the face and crown of a big hill, like the other two working propositions, and is in almost every way like them, with the advantage that it lies within 2½ miles of a water-power capable of developing about 4,000 h.p. It is also

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on the line of the proposed Irondale & Bancroft Ry. extension, the subsidies for which were passed last year by the government.

A third company, known as the "Corundum Refiners, Limited," are now investigating this new find, and have applied to the legislature for incorporation. Thus it is altogether likely that a third large producer will be in operation shortly in Ontario.

Having now reviewed briefly the corundum development in Ontario, let us look at some of the properties of the mineral itself, and its modes of occurrence. Corundum is aluminous trioxide Al_2O_3, but not absolutely pure, as oxides of other metals are usually present to some degree, causing a coloration to the Al_2O_3, so that we find corundum of all colors; I have seen it in the field varying from pure white and clear or colorless through greenish, reddish, blue, gray, bronzy, brown to almost black. A very noticeable thing about corundum, perhaps the most noticeable, is its great hardness, exceeded only by the diamond; this fact helps greatly in the prospecting of corundum, for the exposed surfaces of the rocks carrying corundum always show this mineral standing right out of the general ground mass, and in many cases loose crystals of corundum are lying in small hollows of the rock where they have weathered completely out of the softer ground mass—just as the harder fossils are found lying in loose heaps along the face of a limestone cliff, from which they have weathered. Another noticeable thing about corundum is its high specific gravity, and this will impress one at once on picking up a piece of rock carrying corundum. Its specific gravity is about 4, while that of feldspar, quartz and other vitreous minerals rarely exceeds 2.5 to 2.8. This high specific gravity of corundum then is its salvation, for it is on this principle that it is separated from the feldspar gangue, just as any other metallic oxides or sulphides are treated by concentration to-day. The very marked parting of corundum parallel to the basal plane, and to the rhombohedron, cause the mineral to crush into angular grains which are best adapted to grinding, by offering angular points when made up into wheels, paper or other class of abrasive.

Corundum in the United States is of rather limited amount,

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but the various modes of occurrence are remarkable, e.g., corundum has been found in the following associations: peridotite, enstatite, serpentine, chlorite, schist, amphibolite, norite, minette, audesite, syenite, crystalline limestone and mica-schist.

The most of these occurrences are of scientific interest only, and the peridotite occurrences in North Carolina are practically the only producers in the United States now.

Corundum has been found in Ontario only in four associations. The first, as we saw above, was in crystalline limestone. This is of very rare occurrence, although many of the other finds are in rocks associated very closely with crystalline limestones. Corundum has been found in the crystalline limestones of New Jersey, but here, too, the mineral is very sparingly present, but very pure in quality, and are really gem varieties, being ruby and sapphire. As we saw above, the corundum in the crystalline limestone of North Burgess, near the town of Perth, Ontario, is very sparingly present, but here, too, the crystals are of great purity, the rose-colored ones being closely related to rubies.

The second mode of occurrence in Ontario is in a basic rock, viz.: anorthosite, which is a syenitic rock composed for the most part of the most basic plagioclases, e.g., anorthite, labradorite, etc. This type is made up almost entirely of bytownite feldspar, with patches of green horneblende, very subordinate in amount to the feldspar. This rock carries a very small percentage of corundum, rarely averaging more than 2 per cent. and for the most part does not approach this. The rocks of this class are found in the district about Sharbot Lake, on the Kingston & Pembroke Ry. They resemble very closely the corundum-bearing norites of New York State, and the corundum anorthite of Russia.

The third mode of occurrence is in a more acidic rock, namely, a nepheline syenite. This is a rock in which the feldspathoid mineral nepheline takes the place of a true feldspar, thus giving a rock more acidic than the anorthosite but less acidic than the true syenite, where the acidic feldspar is present.

In this third class of rock, i.e., the nepheline syenite, we find much more corundum than in the anorthosite. The nepheline syenite is also noteworthy as carrying the beautiful blue corundum

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found in Ontario. All the blue or white corundum so far found has been in this rock. Here, too, for the first time, we meet the corundum in economic quantities, for it will sometimes run as high as 10 per cent. of the rock, but rarely averages this. The occurrence of corundum bearing nepheline syenite is unique in Ontario, as it has been reported from no other country thus far. The nepheline syenite area is found chiefly along the York and Madawaska Rivers and in the district about Bancroft. This district was surveyed and studied by the late Alexander Murray in 1853. In mapping the York Branch River he noted the rock occurrences as well. We find in his reports in many places the term mica-slate, and this we found to be nepheline syenite, which in many places carried corundum in large crystals protruding from the soft nepheline, and was of a deep blue color, affording very beautiful specimens, some of which are a close approximation to sapphire.

The fourth, and most important mode of occurrence economically is that in pink syenite. A still more acidic rock, where the feldspar, albite, is the most important constituent, with a very little mica and magnetite in scattered grains through the rock. This, the most acidic rock thus far found carrying corundum, also carries the largest percentage of that mineral. All the working propositions to-day in Ontario are in this class of rock, and the general run of the ore at the working deposits now is about 10 to 15 per cent. corundum, and I have seen tons of rock in these pits that would run 40 per cent. corundum, but never saw such rich pieces in any other class of occurrence.

Whether there is anything in the theory of increase of corundum, with the increase of acidity in the rocks rich in $Al_2 O_3$, so long as there is no fine silica crystallized out as quartz, I am not prepared to say. But nevertheless it is an interesting fact that such is the case so far in Ontario.

Up till the present time I have not seen corundum reported in a granite in Ontario, and, as a rule, when quartz comes into the syenite dikes, as it often does in the dikes of the corundum belt, the corundum has been absent, and use is made of this fact in prospecting for it.

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On one occasion, however, while prospecting in Renfrew county I found a large drift boulder, and although it was composed of quartz and pink feldspar in about equal proportions, and thus making a pegmatite or really a very coarse granite, it was found to be thickly studded with corundum. I searched for the rock in place but was unable to find it, but the usual corundum bearing syenite was found a short distance to the northeast of this float boulder. Experience then has shown that the pink syenites carry the highest per cent. of corundum, and these, moreover, are the best adapted for working. The syenite occurs in dikes and can, therefore, be followed almost as easily as a fissure vein. The feldspar is pink, while the corundum in these syenites is bronzy or brown in color, so that cobbing is readily done on the mined rock. The feldspar has well-developed cleavages, and the corundum well-defined parting, so that, after crushing and treatment by rolls, the products are well broken free of each other. The specific gravity being so widely different in feldspar and corundum, makes the separation an easy matter on Overstrom or Wilfley tables, so that nature has accommodated the best working conditions with the richest deposits.

The other class of occurrence of economic value mentioned was the blue corundum in the nepheline syenite, but here the conditions are not nearly so good. In actually working the deposits, opening the best one on the York River, in Hastings county, we found that this finer grained, and more or less schistose rock, did not break nearly so well as the pink syenite. A schistose or tough rock never does blast out like a brittle hard rock. Moveover, the nepheline does not break readily from the blue corundum, so that small pieces of nepheline are left adhering to the corundum after milling. Again, nepheline itself is of a bluish white color, and on a freshly broken face it is almost impossible to tell which is corundum and which is nepheline. This is easilv done on a weathered surface, or when the corundum is distinctly blue, but these cases are not often found, and certainly would not be found in working a nepheline deposit for corundum. These facts would make cobbing very difficult, if not impossible, in a practical way, so that there is a serious disadvantage, and no

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corundum deposit so far found will stand to mill the "regular run of the mine," cobbing is always necessary.

To conclude briefly I would add, that the question of abrasives has become an important one in the industrial world, so much so that artificial abrasives are now being made. The old abrasives, e.g., grind stones, emery wheels, garnet stones, crushed steel, pumice, bort-saws, etc., are now largely replaced by corundum wheels or artificial abrasives, e.g., corundum or artificial corundum itself.

The production of carborundum is now a big industry at Niagara Falls, where, by utilizing the great Niagara water power, an electric voltage of 2,200 is transmitted to the furnace room of the works through a copper cable. This current is lead in at either end of a brick furnace filled with a charge of sand, coke, salt, and saw dust, this is fused by the electric current and, at the end of 36 hours, the furnace is torn down, and about 7,000 pounds of carborundum is secured. The carborundum is left in large crystalline masses which are put through a crusher, then treated with $H_2 SO_7$, which dissolves any impurity but leaves the carborundum unattacked. The other classes of abrasives are familiar to all.

Corundum has two uses in the commercial world: 1st, as gems for various purposes. 2nd, as abrasive. The first use is underestimated by most people to-day, as corundum is of great use, independent of its ornamental character, e.g., as settings in watches, corundum plays an important part, an evidence of this is seen in a notice from a Swiss agency, for the supply of jewels to watch-makers, to the effect that 75,000,000 watch jewels are required annually by the watch firms.

As an abrasive, corundum is used in three forms: 1st, as wheels or stones of any shape, according to requirements. 2nd, as corundum paper. 3rd, as corundum powder.

The last two need no explanation, but a few words on the former may be in place. There are three classes of wheel made by manufacturers, viz.: the vitrified, the chemical, and the cement wheel, the names being derived from the method of manufacture.

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The grain of corundum used in any one wheel is uniform, but of course varies in different wheels.

In the vitrified wheel the corundum is mixed into a paste with a suitable bond, this is molded to the required shape, then dried in a kiln till sufficiently hard to handle, then dressed to shape in a lathe or other machine, and the stone put into other kilns and heated to a white heat, the furnaces are then cooled slowly, and a very hard and durable bond is the result.

The chemical wheel is much simpler in its make up. A silicate of Na. or K. is mixed up with the grain corundum and the whole moulded into shape, then dried at 300 to 800 in an oven, and left for 24 hours. This method is of special use for manufacture of large wheels, some of these are now made weighing over one ton each.

The cement wheel is simply a mixture of grain corundum with some soft cementing paste, made from shellac, rubber or other compounds, and produces a wheel for ordinary grinding, as saws, tools, cutlery, etc.

The uses of the corundum paper to replace emery paper, and of flour or grain corundum in polishing and other surface grinding needs no comment.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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Journal of the Canadian Mining Institute, Vol. VII.

NOTES ON SOME WESTERN COALS.

By Prof. J. C. Gwillim, Kingston, Ont.

Toronto Meeting, March, 1904.

These notes are a resume of a talk given to the Eastern Ontario section of the Institute. No pretense is made of treating the subject fully.

A common impression has prevailed that the coal beds of the plains and mountains in Western Alberta and Eastern British Columbia are of one period—the Cretaceous—and that the varying qualities of this coal from poor watery lignite to anthracite are due to changes induced by the proximity of the mountains.

This is not so. The coal belongs to distinct periods and is probably of different origin, as Lower Cretaceous, Belly River, and Laramie in succession upwards.

The *Lower Cretaceous* comprises those areas within and closely adjacent to the main range of the Rocky Mountains proper (Crow's Nest, Blairmore, Frank and Canmore), it carries coals varying from bituminous to anthracite, according to local changes, but no lignite as far as known. These beds do not appear—probably do not exist—far east of the foot hills, or on the main plains.

The *Belly River* series outcrops some distance east of the foot hills, as at Lethbridge. It does not appear west of this line nor far to the east, and, therefore, it also does not underlie the great plains between this line and the Red River. It carries a stray lignite coal considerably in demand for domestic and steam purposes, and varies in quality, but being of a distinct period remains within the limits of a lignite.

The *Laramie* is a newer period superposed in large patches upon the foot-hill country, between the Belly River and the mountains. This carries a lignite coal, also varying in quality, especially in the matter of contained water, as shown by Dr. Hoffman in his study of these fuels.

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The Laramie overlies all the country about Edmonton, Calgary, Conley, and contains much lignite coal. It also extends as far east as Estevan and Turtle mountains in the Souris country, and furnishes a lignite coal now being worked at Roche Percée and Beinfait.

Considering these coal series as being of distinct periods and of original organic difference, it will be seen that proximity to the mountains is not the chief factor in producing true coals, but a difference in geological age and conditions. The lignite remains a lignite, but of improved quality, and the bituminous coal becomes occasionally as low as 6 to 10 per cent. in volatile matter, owing to local influences. That is to say, there seems little doubt that a single seam if traced up may change from 20 per cent. volatile matter to less than 10 per cent.

From the nature and origin of coal as an accumulation of vegetable matter in shallow, fresh and brackish waters, one would not expect perfect continuity or equal thickness in the seams. There may have been, as there are to-day, more or less isolated swamps and estuaries. Hence the coal seams are often quite irregular, especially where shearing and mountain making has been in evidence, but the coal *series* are remarkably persistent and often confined to rather narrow horizons, yet containing an immense amount of coal.

Mr. W. W. Leach in his Geological Survey report for 1902 gives a section at Cat Mountain, Blairmore district, where the series is 742 feet thick, the *coal* being 125 feet of this, and on Byron Creek, south of Frank, another section 479 feet containing 102 feet of *coal*.

Concerning the *amount* of coal underlying this foot-hill Rocky Mountain country, it is very great. The present condition, however, demands only the best qualities, such as good steam, coking, and a limited amount of domestic coal. Transportation is by rail and costly. The market is confined to a limited radius, but is benefited by the absence of equivalent coals in some of the outlying territories and of the Western States.

The interior of British Columbia has some sporadic areas of a more recent age than the Cretaceous. The coal in these is often

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of fair quality, sometimes bituminous and of sufficient extent and thickness to become a commercial quantity of considerable importance for local traffic and industry.

On the islands of the coast, Vancouver and Queen Charlotte Islands, and east of Port Simpson on the mainland, these bituminous cretaceous coals are of large extent. These have a wider market before them by means of sea carriage and for the trade and industries of the Pacific, since the Pacific States of the Union are wanting in good coal.

Local conditions have also at these places produced an improvement in the coal, subsequent to its formation, giving a semi-anthracite in the Queen Charlotte Islands and a reported anthracite in one of the lower seams of Vancouver Island.

A fine analysis in round numbers, more or less typical, may help to illustrate these various coal fields:

	Water	Fixed Carbon	Volatile Matter	Ash
LARAMIE				
Souris Lignite	15	35	40	10
Cowley "	6	59	30	7
BELLY RIVER				
Lethbridge Lignite	6	50	32	10
LOWER CRETACEOUS				
Blairmore—Frank	1—4	60—65	20—30	5—20
Crows' Nest	....	60—80	15—35	5—20
Canmore	1—2	80—85	10—14	2—8
Anthracite and Cascade	1	80—89	6—10	3—10
B.C. INTERIOR				
North Thompson	2	47	38	18
Collins Gulch	2—5	50	37	8
Mida	2—3	48—57	34—38	5—13

As before stated these are generalized. The coals vary locally, owing to changes subsequent to the age in which they were deposited.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

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Journal of the Canadian Mining Institute, Vol. VII.

MINERAL PRODUCTION OF ONTARIO IN 1903.

By Thos. W. Gibson, Director Bureau of Mines, Toronto, Ont.

Toronto Meeting, March, 1904.

The total value of the mineral production of Ontario in 1903, as shown in the table which I have the honor of submitting herewith, was $12,870,593. Of this, metallic products contributed $5,242,575 and non-metallic products $7,628,018. The total is about 4 per cent. less than that for 1902, the reduction being wholly in the products included in the metallic list. The precious metals gave a smaller return than in 1902, gold falling off considerably and silver still more so, the latter due to the stoppage of the silver mines west of Port Arthur. The gold mills in western Ontario ran intermittently during the year, and in eastern Ontario only one was in operation at the close. The principal decreases were in iron ore and steel. The Helen iron mine was affected by the paralysis which befel the great industries at Sault Ste. Marie, and was shut down before the shipping season was over. The Algoma Steel Works, another of the Clergue enterprises, ran for some months in 1902, but remained with closed doors during the whole of last year, thus reducing the output of steel to the previous level. Pig iron also fell off somewhat. On the other hand there was a considerable increase in copper, the yield of which, as contents of ore and matte, showed an advance over that of 1902 by 471 tons in weight and $36,443 in value. There was also a record production of nickel, the output of which was 6,998 tons, worth in the matte, $2,499,068. This exceeds the production in 1902 by 1,053 tons in quantity and $288,107 in value, and confers upon the Sudbury district the distinction of being the chief source of the world's supply of this metal. As in former years, the principal producer was the Canadian Copper Company, but the Mond Nickel Company and the Lake Superior Power Company also contributed to the total. The works of the

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first named company are now being extensively overhauled and re-modelled with the view of producing a high-grade matte by the Bessemer process.

Of the substances comprised in the non-metallic list several show fluctuations from the level of 1902. The total, however, exhibits an increase of about 7 per cent. Carbide of calcium gained 1,105 tons in quantity and $54,580 in value, testifying to the growing popularity of lighting by acetylene gas, notwithstanding the mishaps which occasionally result from its use in careless or incompetent hands.

There was a small gain in corundum, which is of abundant occurrence in Hastings and Renfrew counties. Two companies are now producing the crushed and sized article, with prospects of a third. The pioneer concern, the Canada Corundum Company, is erecting and equipping a plant of much greater capacity than its old one.

Feldspar was in good demand, the output being mainly of the potash variety. Shipments for 1903 were in excess of those for 1902 by 6,520 tons in weight and $7,171 in value. It all goes to the United States, where it is used in the manufacture of pottery and for glazing tiles, baths, enamelled ware, etc.

Graphite was raised to the extent of 4,400 tons from three properties during the year, being double the quantity returned for 1902.

There were raised 3,098 tons of iron pyrites more than in the previous year, principally in Hastings county, and the aggregate production was greater in value by $6,700. The output is sent to United States markets, principally Buffalo and Cleveland, for the manufacture of sulphuric acid.

The yield of mica was almost exactly the same as in 1902. The production of this article is now confined more largely than formerly to companies working on an extensive scale, and since the introduction of "micanite," in which the smaller sizes are utilized, the demand is not so much for size as for quality. The General Electric Company operated the well known Lacey and

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Hanlan mines during the year. The former mine yields crystals of enormous size, some having a width of as much as 81 inches.

The value of the natural gas produced last year was very little less than in 1902. Much the larger proportion now comes from the Welland field, that in Essex county having been practically abandoned owing, it is said, to the exhaustion of the gas. A pool at Dunnville, Haldimand county, is being exploited, and gas is now being obtained in small quantity at Brantford.

Petroleum, of which the Lambton county oil fields remain the chief source, is steadily declining in yield. Compared with 1902 the production of crude for 1903 was 1,545,254 imperial gallons less, while compared with 1893 it was 17,414,662 gallons less. In ten years, therefore, the quantity of crude product has fallen off over 50 per cent. The higher prices which prevailed last year, however, prevented the value falling with the production; indeed, there is a decided increase, taking as a basis petroleum products and crude petroleum used for gas and fuel, the increase amounting to $155,620. It is estimated that about 2,200,000 gallons were used for other purposes than refining. It is a legitimate subject of inquiry whether there are not yet undiscovered reservoirs of both petroleum and gas in this Province. The supply of the former has heretofore been taken wholly from the limestone of the Corniferous formation, in which it is found at a depth of about 470 feet from the surface. Borings have been made to the Trenton, which in Ohio and Indiana is the great source of oil and gas, but without much success; recently, however, oil has been found in considerable quantity in the southwest corner of Kent county at a depth of 1,290 or 1,300 feet, in what is believed to be the Guelph formation, and more recently still, at Brantford, oil has been struck in the Medina, at about 500 feet. The diminishing yield of the Ontario petroleum wells is leading to a demand in some quarters for an abolition, or at any rate a reduction, of the duty on imported American crude, as the present production of crude is not at all commensurate with the demand and the refining facilities. The Canadian market takes all the product of the home refineries and also a large quan-

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tity of refined oil imported from the United States. The diverse interests of oil producers and oil refiners would be happily reconciled by the opening up of new sources of supply within the Province.

Salt continues to be raised in about the same quantity from year to year from the extensive beds lying east of lakes Huron and St. Clair. In 1903 the output was somewhat less in quantity and somewhat greater in value than in 1902. In addition to the ordinary uses of this article, it might be made the basis of important industries in the manufacture of caustic soda, bleaching powder, etc.

In building and construction materials, lime and stone both show a decrease in value, the former of $175,000 and the latter of $97,000. These losses are largely offset by an increase in the value of brick amounting to $175,000, the result of active building operations in many centres. There was a further expansion in the quantity and value of Portland cement as compared with the previous year. The development of this industry in Ontario since its commencement in 1893 has been remarkable. In that year 2,033 barrels were made, worth $5,082. In 1894 the output was 30,580 barrels valued at $61,060; in 1897 it was 96,825 barrels worth $170,302; in 1900, 306,726 barrels worth $598,021 and in 1903, 695,260 barrels valued at $1,182,799. Few industries can show a record equal in rapidity and steadiness of growth. The cheapness of cement and the multifarious uses to which it is now being put, ousting as it is to a greater or less extent lime, brick, stone and wood, have led to an enormous demand. This in turn has called into being an industry fast attaining high rank in value of output and amount of invested capital. There were nine producing plants in 1903; five others were approaching completion and will probably place their product on the market during the present year, and two or three other companies are in process of organization. A note of warning may perhaps not be amiss. The market in Canada is not unlimited in extent, and imported cement is competing severely with the native article at the present time, American makers being able to produce, or at any rate to

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sell, on this side of the line, more cheaply than Canadian manufacturers. It would be a pity to overdo the cement business, and there are not wanting signs that the point to which expansion can, for the time being, profitably or safely go has been reached, if not passed.

The only other substance which calls for special mention is peat fuel, of which some 1,100 tons were manufactured by two separate plants last year. The product has given satisfaction, and a larger production may be expected. It is to be hoped that ere long peat fuel from Ontario bogs will largely replace anthracite imported from Pennsylvania in the kitchen ranges of the Province —a use for which it is eminently fitted.

In the foregoing table values have been computed at the selling price at the point of production. The aggregate value of the metalliferous products could have been greatly swollen had the computation being on the basis of the market price of the refined metals. In the case of nickel and copper the additional sum would have amounted to at least $3,600,000, but it appeared preferable to give the actual value as nearly as this can be ascertained in the form in which the metals are sent out of the country, seeing that the additional value conferred upon them by separation and refining has its origin elsewhere and affords no employment to Canadian labor or Canadian capital.

SUMMARY OF MINERAL PRODUCTION IN 1903.

Metallic		Quantity.	Value.
Gold	Ounces	10,383	$188,036
Silver	"	16,688	8,949
Copper	Tons	5,331	716,726
Nickel	"	6,998	2,499,068
Iron Ore	"	208,154	450,099
Pig Iron	"	87,004	1,491,696
Steel	"	15,229	304,580
Pig Lead	"	25	1,500
Molybdenite	"	85	1,275
Zinc Ore	"	1,150	17,000
			$5,673,929
Less value Ontario ore smelted into pig iron, and pig iron converted into steel			436,354
Net value metallic production			$5,242,575

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Non-Metallic		Quantity.	Value.
Actinolite	Tons	550	$1,650
Arsenic	"	257	15,420
Tile, Drain	No.	18,200,000	227,000
Brick, Common	"	230,000,000	1,561,700
Brick, Paving	"	3,788,800	45,288
Brick, Pressed and Terra Cotta	"	23,702,610	218,550
Building and crushed stone		.....	845,000
Carbide of Calcium	Tons	2,507	144,000
Cement, natural rock	Bbl.	89,549	69,319
" Portland	"	695,260	1,182,799
Corundum, Grain	Tons	849	84,900
" Cobbed	"	270	2,700
Feldspar	"	15,296	20,046
Graphite	"	4,400	20,636
Gypsum	"	4,520	7,910
Iron Pyrites	"	7,469	21,693
Lime	Bush.	3,400,000	520,000
Mica	Tons	948	102,205
Natural Gas		.....	196,535
Peat, Fuel	Tons	1,100	3,300
Petroleum	Imp. gals.	16,640,338	
Illuminating Oil	"	7,096,073	
Lubricating Oil	"	2,614,313	
Benzine and Naphtha	"	832,153	1,586,674
Gas and Fuel Oils and Tar	"	1,968,172	
Paraffin Wax and Candles	Lbs.	2,673,806	
Pottery		.....	160,000
Salt	Tons	58,274	388,097
Sewer Pipe		.....	199,971
Talc	"	920	2,625
Total Non-Metallic production			$7,628,018
Add Metallic production			5,242,575
Total production			$12,870,593

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DISCUSSION.

THE PRESIDENT—I am sure you will all agree with me in thanking Mr. Gibson for his valuable paper, and in producing proofs of what Prof. Miller said this afternoon of the value of the Ontario mineral resources. These figures which Mr. Gibson has just given us demonstrate clearly the importance of the mineral resources of this province.

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MR. STEVENSON BROWN—In connection with Mr. Gibson's paper, to which I have listened with interest, there is one particular subject, viz., that of cement, to which he referred, and which is of special interest at the present time. I have read the report of the expert who examined the buildings after the recent Baltimore fire, and his statement is, that in classifying the building materials which offered resistance to the fire, cement came first, brick second, steel and iron third, granite fourth, sandstone fifth and mortar sixth. This brings cement as a building material prominently to the front, and as Mr. Gibson has said, a new industry is bound to be opened up in Canada in connection with the making of cement to be used in the construction of buildings. I cannot but think that Mr. Gibson's paper must be of very great interest to us all, and I hope that what he has said with regard to cement may have the effect of strengthening the growth of the cement industry in Canada.

MR. MORRISON—I had occasion last year in the interest of a client to make a careful examination of the official statistics of Germany, Great Britain, United States and Canada with regard to the cement industry. I also investigated its industrial usefulness, cost of production, indicated channels of trade, etc., and I am thoroughly persuaded that we are on the eve of a cement age. There is no doubt the day of clay brick for the erection of business blocks and warehouses is about over. Hundreds of companies were organized in the United States last year for the manufacture of sand brick and cement building blocks. This class of building material is eminently suitable for residence construction and ordinary warehouses. The buildings erected in Philadelphia, New York and other large American cities within the last two years, where immense constructions up to 12 stories have been erected altogether without steel frames, of Portland cement concrete, and have shown—so I am informed—to have less vibration and greater convenience, safety and usefulness than similar buildings erected in a more expensive manner, indicate the rapid increase of the use of Portland cement in building operations. Building operations with Portland cement concrete can be carried on by

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ordinary laborers, and I have no doubt that so soon as the building trades will adopt it, it will have an important effect on the conditions of the labor market and the domination of trades unions. We know, in Toronto, that over and over again, during the past twenty years, the continued strikes in the building trade have not only wrought ruin to the builders, investors and general progress, but have so increased the cost of building as to necessitate exorbitant rents and make this a very expensive city to live or do business in. The finest fire-proof, durable, ornamental and substantial buildings can be built of Portland cement concrete in a simple manner and at a low cost.

But the building trade is only one of the many uses for cement. The construction of permanent work in great lines of railways, municipal roadways, city streets and pavements, public works, such as canals, docks, piers, tunnels, subways, sewers, water aqueducts and conduits, reservoirs, breakwaters, etc., has been shown to be much more permanent in character and usefulness made of Portland cement than of any other material.

We have an unlimited supply in Canada, of raw material suitable for its manufacture, in every province and practically in every locality. The mechanical and chemical conditions of economic manufacture are well understood and I am of opinion the industry has a great future in Canada.

PROF. MILLER—Before I forget I wish to say that the Canada Corundum Company desires to present the gentlemen present at this meeting with a number of articles manufactured from their corundum, as souvenirs. We are indebted to Mr. Craig for this. I may say that the manager of the company is also preparing an exhibit of articles for the St. Louis Exposition, and in his advertisement he makes a statement which I would not like to quote unless it were by poetic license. However, the manager tells me that they will not object to his advertisement in Missouri although they might in Ontario. He describes his corundum as "hard as hell" (laughter).

MR. THOMPSON—Probably I could give you a peculiar illustration of the value of cement in mine construction work. I think

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Dr. Porter and several of the McGill gentlemen can bear me out in what I say regarding the practical use of cement at the new plant of the Le Roi mine, constructed in 1901. Mr. McDonald was then manager of the mine and I was assistant, and he instructed me to see that the machinery was properly installed. We found that in each case the plans furnished by the machinery manufacturers showed masonry foundations. My experience previously was that within six or eight months from the time that the machinery started, our machinery was wobbling around as if it were on a beam. In order to get away from this, and also because of the high cost of labor—"bricklayers demanding $6 for an 8-hour day"—we built all our foundations with ordinary mine rock, local sand and Portland cement. The result has been extremely satisfactory; in one particular case we had to erect a 660 K.W. motor, the conditions were exceptionally severe on the foundation that this method was followed and I am pleased to say that machine ran 24 hours without a stop; and to-day, after being used from the early portion of 1901 to the present, the foundations never have had to be leveled. In one case machinery worked on a concrete foundation was given daily service, except for such difficulty which occurred within the machine itself, and in another case the machinery worked on a masonry foundation has been shut down for a large portion of the time owing to the fact that it is almost impossible to keep the foundations tight. As far as the physical examination of the product of some of the cement manufactured in Ontario is concerned, it seems quite equal to some of our best imported brands, but outside of a desire to use ordinary cement, I find that our architects, and more particularly the architects in Toronto and Montreal, seem to have the idea imbedded in their craniums, that cement equalling the imported cement cannot be obtained here. I think that is a great mistake, and if these gentlemen would consider their own country a little more seriously probably the imports of cement would be reduced and the consumption of the home products would be largely increased.

MR. HOBART—The many advantages of cement came under my notice in the anthracite coal country, where in one mine they

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have put down a new shaft which is entirely lined with cement. The Lackawanna Company are putting down two large shafts, which are treated the same way. One shaft is 700 or 800 feet and the other 500 feet, and they will be lined with cement.

MR. THOMPSON—While we were doing the cement work at Le Roi we had a visit from a gentleman of whom every Canadian has reason to be proud. I refer to Mr. James J. Hill, the President of the Great Northern (applause), who came there with his engineering staff, and after watching the construction he was very much impressed with it and made enquiries as to the strength of the materials and so forth. Wherever they have erected new bridges since on the Great Northern they have followed exactly the same method that we adopted in the case of our construction. Instead of using cut stone for the erection of piers and bridges, they have made a mould with mixed concrete, and for some years past they have entirely discarded masonry work and introduced mixed cement cast in solid form.

MAJOR LECKIE—In sinking the shaft at Silver Islet thirty years ago, Mr. Frue used a good Canadian cement, and forty years ago, I used it in a wet shaft at Vale mine, Acton. Therefore, there is nothing novel in the use of cement concrete for sinking shafts to-day. There are a great many other things in which we Canadian engineers are in advance of the Americans.

THE PRESIDENT—This is a very important question for us, and we are glad to hear of all the uses that engineers are making of cement. No doubt the use of cement will become very general for all sorts of foundation work and for shafts, and so there will be great benefit to our cement industry in Canada.

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Journal of the Canadian Mining Institute, Vol. VII.

THE GEOLOGICAL SURVEY OF CANADA AS AN EDUCATIONAL INSTITUTION.

By T. L. Walker, University of Toronto.

Toronto Meeting, March, 1904.

During the second quarter of the last century the investigations of geologists first received general recognition from those interested in the mineral industry. Then for the first time did the governments of progressive peoples seriously consider the wisdom of engaging trained scientists to examine systematically the lands under their controls with a view to learning the extent of their mineral wealth and the best methods of exploitation.

The Geological Surveys of England, India and Canada were formed during this period. In this country the Survey was to be an economic institution, but this, at times, necessitated the study of theoretical questions. Experience has shown that the two branches—economic geology and pure geology—must be taken up together, if the best results are to be attained. Of late it has often been urged that the Survey devotes too much time to purely scientific geology to the detriment of its economic work. The members of this Institute are agreed that too little exploration of the latter kind is attempted, but that can only be remedied by a larger staff and more generous support on the part of parliament. I regard the scientific work as absolutely necessary if we are to achieve the best economic results.

It was impossible at first for the director of the Geological Survey of Canada to secure in this country men trained in geology and in the other branches of science required of those who attempt such work. Sir William Logan collected a staff, mostly untrained men—lawyers, masons and farmers—and in a short time they were doing work which has since become classic, not only for us in Canada but for all the world.

This was the beginning of the educational work of the Survey.

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Large editions of the reports of the geological explorations are distributed either free or at a nominal price to those interested in geology and mining. This, too, is an educational side of its work which has been well sustained for half a century.

There is only one other method to be pointed out—the distribution of specimens of mineral rocks and fossils from Canadian localities to schools, libraries, colleges and learned societies. As a result of this there are now scores of collections accessible to thousands of students and scholars in all parts of Canada. I do not know just when this method was introduced, but I am glad to say that this is still a very fruitful branch of the Survey's educational policy.

It may be maintained by some that the Survey has no educational duties to perform, or that the work mentioned is only of very minor importance. I hold that it has had such a policy from the beginning, because it was early recognized that with the intelligent co-operation of mining engineers, college graduates and enthusiastic amateurs, much more could be accomplished than would be possible to a small group of state paid geologists working alone. At present Canada has very few trained field geologists in proportion to the great areas of unexplored territory. Apart from the work done by the state geologists very little has been accomplished. In England, France and Germany there are scores of amateurs who are doing work of the highest class. If in Canada we could only encourage the growth of such a band of volunteers the advance of geological exploration would be much more rapid.

The absence of well-trained field geologists is much spoken of by those interested in the development of the mining industry. Competent leaders for exploring parties are scarce. It has been said that some years ago, at the time of the opening of the Yukon, if the offer of a certain firm to build a railway from the coast to the gold regions in return for extensive concessions in mineral lands, had been accepted, a large fraction of the staff of the Survey would have resigned their posts and taken appointments with the company. We cannot tell what might have been—such things are uncertain—but we do know that a large number have resigned

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their appointments on the Survey and gone into private work. There is a demand for trained men but no supply. This is evidence of the absence of a sufficient number of competent field geologists. The Survey has almost ceased to regard the training of geologists as one of its functions.

The universities and schools of mining may be thought to be responsible for this scarcity. We can give students a thorough training in certain branches of the subject, but in order to give field experience, it would be necessary for us to send out real exploration parties for several months every summer, and so far as I know no Canadian college has been able to do this. It would be expensive and apparently unnecessary when one reflects that the Survey sends out over thirty such parties every summer. Year after year the best students in geology apply to their instructors for letters of recommendation, and send formal application for permission to accompany a field party of the Survey. They do not understand why it is that they fail in these applications. For ten years no advanced student in mineralogy, geology or mining, from the University of Toronto, has been able to secure a place on any of these expeditions. I know of some cases in which men quite innocent of any of these subjects have been sent out as field assistants, able neither to assist in the geological work nor to profit by the summer spent in the field with a trained geologist. Now I shall not undertake to explain the cause of this. We are in many respects like our cousins to the south of us. In the United States it was found very difficult to secure the appointment of the best men for such posts and it became necessary to make their Geological Survey a sort of commission almost independent of the ordinary methods of selection. Now the director has no difficulty in finding out the best men. Is our problem capable of being solved in the same way?

In conclusion, I wish to repeat, the Geological Survey of Canada is, and has been from the beginning, an educational institution. In its generous distribution of its reports and of geological specimens it is following the right path; it has almost ceased to co-operate with the Canadian universities, their best students finding it next to impossible to get field training on the summer

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parties of the Survey. Some even apply to the United States Geological Survey for permission to join their field parties. Advanced students want field training, and would in some cases be willing to go as volunteers without pay. For Toronto students at least the door has been shut for ten years.

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DISCUSSION.

DR. ADAMS—In recent years the very important services which the science of geology can render to practical mining are becoming more and more widely recognized, so that most of the large mining companies in the United States and elsewhere have either a geologist as a member of their permanent staff or have a consulting geologist who is called in when any problems which require his assistance present themselves. In the United States, the Geological Survey of that country serves as a most efficient training school for such geologists, for students, while gaining a thorough knowledge of the principles of the science and of the methods of field work in the universities and science schools of the Republic, may secure temporary positions during the summer as junior assistants in the field portion of the Survey, and thus get that continuous practical experience in geological field work which is necessary to enable them to readily apply their knowledge to any problem in stratigraphy or any questions bearing on the relations of ore deposits which they may be called upon to investigate.

In Canada our Geological Survey has in the past given to a large number of young men from our universities a similar training, among whom may be mentioned Messrs. Lawson, Carlyle, Tyrrel, Brock, Gwillim, Barlow, Low, McConnell, and many others; men whose subsequent work fully testifies to the value of the training in field work which they have thus received on the Survey parties. Young Canadians with such a training in our schools of science and having experience in the methods of solving the geological problems which present themselves in our own

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territory are in a position to render the most important services in the development of mining in the Dominion, as well as in carrying out exploration work of the highest value in the newer districts of our country which are being continually opened up. Enthusiastic students of geology, moreover, while extending their winter training in the university by summer work on the Survey, will prove much more valuable assistants than those who know little or nothing of the work which they are called upon to undertake, and who join field parties without any design or intention of making use in after life of the knowledge which they thus obtain.

I think, therefore, that the Institute might with advantage bring to the attention of the Minister of the Interior the very important services that could be rendered, not only to the Geological Survey itself, but to the numerous industries of the Dominion at large, by making it a practice to take as assistants on the Geological Survey only the best students in the geological and mining courses at our universities, and thus continuously have in training a number of young men who were being fitted in the most thorough manner for advanced work in mining geology. The Geological Survey could, I believe, thus add one more to the many services which it already renders to the mining industry of Canada.

MR. CRAIG—I think I may say a few words on this subject because I have had practical experience of the crying need for improvement in geological training. I know for a fact that there is not sufficient information available to enable capitalists to invest their money in mining enterprises in Canada. There are a great many shrewd men who are interested in mining and who also share this opinion with me. In the United States, mining has developed until it is somewhat of a science; you can get men who are thoroughly acquainted with the conditions existing there and capitalists can get an intelligent opinion from them. Our Canadians are not by any means lacking in energy, but it is nevertheless a fact that it is almost impossible to get any Canadian who has the training that would justify an investor in taking him as a safe guide. There are in Canada only a few, not more than

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a very few, men whose advice is worth three cents. There are, I believe, about 750 stamps in Ontario alone, and that means a good many millions invested in this industry, but these 750 stamps are one and all lying idle to-day, and one of the chief reasons is that some of them have been installed on advice that never should have been given. If we are to make this country a mining country we must begin at the bottom; we must lay our foundations before we can build the superstructure. Therefore, the first thing is to have men who understand the formations and who can tell where there is ore and where there is not. I have seen shafts put down in certain places and you might as well sink them in the city here and expect to find gold. I have had occasion to have work of that sort done, and I found it very difficult to get men who had even the first conception of what they were to do when they were dropped into the field. We want our men trained in field work. What is a man worth as a geologist who cannot go a few hundred yards in the bush before he is lost? What is the use of a man in the Ontario backwoods who cannot handle a paddle? You cannot expect our students to get all the training that is necessary at the university. There is something else required, and that something else they can only get by actual experience in the field. It is my strong belief that students should be carefully selected by the government survey parties so that they may be given a chance to learn.

DR. PARKS—I wish to endorse the remarks of Professor Walker and of Dr. Adams on this question. While not wishing to be personal, I know by experience that it is a very difficult matter for students to obtain such positions as they desire on government survey parties. On several occasions I have known of applications having been made by desirable students without success. The first time I went into the bush in Ontario I had not had any field experience, such as that spoken of, and it took me some time, long after graduating, to acquire the knowledge that might have been obtained during the long vacations of my student days. For this reason I consider that this is a matter of very considerable importance, and I think that the Institute should take some action.

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I should also like to take exception to the remarks of Mr. Craig. He is inclined to attribute the blame of many failures in Canada, and more particularly in Ontario, to the lack of competent men. He is putting it on the wrong shoulders. A great majority of the failures are not owing to the lack of men competent to express an opinion, but rather to the lack of willingness on the part of operators to pay men who are capable (hear,hear). I am quite sure that in the gold mining industry of northern Ontario, the failures have been largely owing to the employment of men who know absolutely nothing about the work, rather than to the fact that competent men can not be obtained. I recall, among other cases, that of an entirely inexperienced man being sent out in charge of a large prospecting outfit. He knew absolutely nothing about mining, but he was put in charge of this work and the first thing he did was to carry a road, some 40 feet wide, through the bush in order to get machinery in. To show the absolute ignorance of that individual, he had some pyrite, stained by weathering, which he confidently informed me was covered with gold. This opinion was based on information derived from an expert from Rat Portage.

PROF. MONTGOMERY—I feel that this is a very important subject. The character of the questions dealt with at this Toronto meeting has been such that the Institute ought to be congratulated, and probably also the country. I feel that when the director of the Geological Survey of the Dominion of Canada and other members of the staff, and professors from the great universities and other institutions in Ontario and Quebec, and experienced well-known mining engineers from various parts of Canada, when these gentlemen go to the trouble of coming long distances to attend these meetings, it seems to me that the Institute has reached a point in its history that really makes it of importance to the whole country. I strongly endorse the appeal made by Professor Walker, and I think that any action taken by this Institute under these circumstances should have very great weight with the people of this Dominion. It is a most important matter that our young men should have proper training. I do not see how you can expect young men to enter very enthusiastically

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into this work unless they can see something ahead for them in the future; unless they can feel that there is some reasonable certainty of gaining proper compensation. As Professor Adams has well put it, geology is the foundation of mining, and on the other hand mining is of very great assistance to geology. Some very useful work in the past has been done by Prof. Newberry, our late esteemed Prof. Chapman (applause), Sir William Logan, and others, who were really not professional mining engineers but who had so much knowledge on all sides of the work that they were extremely useful to the country in their day and generation. We know that there are minerals in Ontario and Quebec, and in fact all over this country, but very little has been done to discover or develop them. We hear the blame laid on different shoulders, sometimes on the investors, sometimes on the mining engineers and sometimes on the mineralogists. However that may be, I believe that if we can put our mining resources before the capitalists of the world, good results will flow from it. It is unfortunately the case, that inexperience in mining has played some part in retarding our progress, but we know that when mines do not pay dividends the shareholders have lost heart. However, the fact ought to be emphasized, that whenever people invest money in mining they should have capable men in charge of their property, so that if any misfortunes and difficulties are met with, these men will be able to overcome them, which would not be the case if the property was in charge of incompetent persons. If that view is kept before the public more frequently, it may be helpful in the future. People do not seem to realize that there must be some risk in mining, and capital is required for prospecting. A good deal of money has been lost in Ontario mining properties, and people are rather chary now about investing. These are the things that help to keep capital back. There are people here who are willing to invest their money in mines if they are sure that they will not lose five cents, but investors have to take the good with the bad, and, with competent men in charge of properties, the chances are strongly in favor of the view that mining investment in Canada will be safe, although, of course, as in even the best mining districts elsewhere, there will be some losses.

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MR. STEVENSON BROWN—I listened attentively to Dr. Walker, I had hoped that he would say something about the men who were trained in our Geological Survey, and who receive but little encouragement from the Government to continue their work and their research. We have in the Geological Survey, a scientific body of men well qualified to carry out the work in which they are engaged; but I regret to say that the facilities placed at the disposal of these gentlemen for carrying out their work are very meagre. How many of them are members of the Canadian Mining Institute? and how many of them have their fees paid by the Government? We have one or two members who pay their own fees and try to keep themselves up to date about what is going on in the geological world, and in the commercial world so far as mining is concerned. These gentlemen have to attend our meetings at their own expense, when the fact is they should be sent here and their expenses paid by the Government. I would be the last to say that the Government has not treated this Institute in a liberal and in a friendly manner; we know that they have assisted us very greatly with our publications, and we are very grateful to the Government for that. But there are other matters in which they could give assistance. I firmly believe that if this matter were brought to the attention of the Government, through the proper channels, the Government would accept our suggestions to make our meetings more accessible to the members of the Geological Survey in the manner indicated.

Then, in reference to what Dr. Walker said, as to the insufficient number of copies of the volumes of our transactions, I may say that I have to-day applications from the Government of Western Australia and also from other Government officials and private individuals asking for back numbers of the transactions of the Canadian Mining Institute, which we are utterly unable to supply. Is this creditable to an organization of this kind; is it creditable to the Government of this country? Is it creditable to ourselves that we should continue to publish only 400 or 500 volumes when we should be publishing at least 1,000 copies of our transactions. I have persistently urged, as Mr. Hardman and Major Leckie know, for the last four or five years, that a sufficient

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number of copies should be printed so that we could have a reserve supply to meet future demands; and I would like some definite action in regard to re-printing the back numbers, including Vol. V, of which we have none left. I trust that this matter will be taken up seriously.

PROF. BROCK—The matter which Dr. Walker has brought to the attention of the Institute is one that is worthy of consideration.

A limited number of student assistants are sometimes of service to a geological survey party, and when they are required they should be selected from the advanced students of geology and mining, since these are better fitted to do the work of student assistants than any others, and the experience they will gain will be of great advantage to them in the future practice of their profession. I think, therefore, that these positions should be held exclusively by students of mining and geology. That the experience thus gained is of great benefit to them in their professional work is shown by the fact that a large proportion of the most successful men in Canada and the United States have got their field training in geology as assistants on geological field parties, when they had an opportunity of studying ore bodies and rocks in their true relations. On the other hand it is to be remembered that it is not the function of the Geological Survey to conduct field classes for the universities. The field geologist has other work to perform, and it is only when such assistants are actually needed that he should be asked to take them. But when such assistants can be used by all means appoint them from among the students who can be of most assistance, who will take the greatest interest in the work, who will need the experience, and whose experience will be of permanent value to themselves and to the country.

MR. CRAIG—I would like to move that the President, Mr. Coste, Major Leckie, Mr. Stevenson Brown, Dr. Adams, Prof. Brock, Dr. Walker, and the mover, be a committee to wait upon the Minister of the Interior and such of the Provincial Governments as may be deemed advisable, to confer with them on the necessity of giving preference to geological students when ap-

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pointments are being made for assistants for the Geological Field Survey parties.

I am sure that Dr. Adams will be heartily in accord with that motion. I myself happen to have some personal knowledge of the difficulty which Dr. Parks mentioned, of getting students on those survey parties. On the other hand, young men who have never had any intention of going on with geological studies have been appointed to this work. I know that Prof. Miller, Dr. Parks, Prof. Brock and others who are to-day our leading geologists had an opportunity of doing field work in their early days. You see what has sprung out of that small beginning in the case of those men, and you see what help it is to geological students to get out on those field parties.

I hope that within ten years we shall have at least six Ontario Government geologists, and we cannot have them unless our Canadian students are given a chance.

DR. BARLOW—Before a resolution is submitted to this meeting containing the recommendation of this Institute that students of geology or mining should alone be eligible for appointment as assistants on the Geological Survey field parties I would like to give a few explanations. Dr. Walker has stated on the authority of the Acting Director that over 30 parties are engaged during the season in different parts of the Dominion in geological and exploration work. This, however, does not necessarily imply that an equal number of assistants is required. On the contrary there are only vacancies for perhaps half a dozen, and certainly not more than a dozen assistants can be advantageously employed. The expenses of transportation in connection with the parties operating in the Yukon, British Columbia, and in a less degree the Northwest Territories are usually too high to permit of the employment of assistants who are resident in the east, unless they have had considerable previous experience. The wages, travelling expenses and other incidental expenses of an assistant in connection with a geological party in the east generally average from $250 to $300 for the season, while the total available appropriation for all purposes for such a party usually varies from $1,100 to

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$1,400 per season. When it is considered that the average assistant is rarely of much service during the first year it seems a large sum for the geologist in charge to pay out of his whole grant. Assistants are generally chosen from applications sent to the Minister of the Interior or the Director. These applications are received for the most part from students of the several universities and schools of science, their letters often receiving the endorsation of certain of the professors, who in addition may write to the Minister or the Director urging their appointment. It sometimes happens that the same professor may endorse the application of half a dozen students without showing any discrimination or endeavoring to point out the best men. I am sure the Hon. Mr. Sifton, who is now Minister, has always shown that he is only too anxious to secure the very best geological assistants, and will welcome any recommendation or suggestion on the part of the Institute which would ensure this proper selection. Personally I have had the good fortune to be assisted by men who intended to make geology or mining their life work and would take this opportunity to express my appreciation of their able and untiring efforts to fulfil their duties.

DR. PARKS—I have not the slightest doubt that what Dr. Barlow says is absolutely correct. I know that the grant of the Geological Survey is inadequate for the enormous amount of work it has to accomplish. Still numbers of young men, not students of science, do receive appointments as assistants even when men with a certain scientific training would be glad to go, possibly without remuneration. This procedure I would, however, by no means advocate.

I have never considered that "pull," as has been suggested, has anything to do with these appointments. The simple fact is that the appointments are naturally given to those known to the authorities, and I am assured, if the great advantage of these trips to students of science is brought to the attention of the Minister, that the matter will be dealt with as we desire.

DR. BARLOW—These men should be paid from whom it is possible to get efficient work out of them.

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DR. PARKS—I agree with that, but at the same time the lack of funds is not the main reason why geological students have not been appointed.

MAJOR LECKIE—I have for years felt that the officers of the Geological Survey have been very inadequately paid; in fact their salaries are nothing more than those of clerks. It is absurd to think that you can get scientific men for from $1,500 to $2,500 a year. You cannot expect young men of intelligence and ability to give their time to the service of the Geological Survey, when they have nothing better to expect than a salary of that kind. We require in the Survey men who will devote themselves to the work, and make it their life object, but men would be foolish to do that in view of such small remuneration. It is quite difficult to retain in the Geological Survey, men of ability for the pittance that is paid in the shape of salaries. I think we should place the whole matter before the Minister of the Interior.

MR. J. M. CLARK, K.C.—I have much pleasure in seconding the resolution of Mr. Craig, and I believe it meets with the endorsation of the whole Institute.

MR. CRAIG—I think the deputation I have named should point out to the Government the necessity of retaining the geologists already appointed upon the Geological Survey staff. With the permission of my seconder I will add this to my motion. The fact now is that that these gentlemen after a few years in Canada are tempted to give their experience and ability to foreign countries, and there are many of these gentlemen whose loss we would deplore. In some cases their services are retained by foreign governments and in other cases they are employed by large corporations who recognize their worth, which the Government of Canada does not.

MR. GIBSON—I would not have spoken on this motion had it not included a reference to the Provincial Governments. I am entirely in sympathy with the sentiment uttered by Dr. Walker, and quite in accord with the resolution. But I would like to say that the Bureau of Mines, which I represent here, ought to be given whatever share of credit it is entitled to on this matter. I

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look upon the work of that Bureau with a considerable degree of pride, one reason being that we have been able from the beginning to associate with ourselves promising students of geology and utilize their services in geological work in the field. It is true that the work done in the Ontario Bureau of Mines is small in comparison with that which is done by the Geological Survey of Canada, and although the money at our disposal may not be as much as we would like it to be, I could give the names of half a dozen bright young Canadians who have been associated with the Bureau and whose field training was obtained largely in the Bureau's service. They were anxious to get the work because they could get that experience, and in their after career they have done credit to themselves and their country. I trust that we will always be in a position to make use of the services of students in geology and mining, and I intend to carry that out so far as I am concerned. Whether these students are subsequently taken into the employ of the Government or not, is not of much consequence compared with the importance of raising up in this country a body of educated men who are thoroughly acquainted with the geological conditions of our country which in many respects are unique, and who can be sent into the field by private individuals or companies that have their own geological or mineralogical problems to solve.

DR. WALKER—I had no reference whatever to the Bureau of Mines in Ontario. Personally I have known of quite a number of students who have been sent out on geological field parties by the Bureau of Mines, and they were carefully selected men of good standing in geology and mineralogy, well prepared to do their work and profit by their experience.

DR. BARLOW—The Geological Survey as an educational institution has done a vast amount of good work. Dr. Adams, Logan professor of geology at McGill University, is proud to remember that his first practical experience in geology was obtained as an assistant on one of the parties of the Geological Survey. Dr. Walker himself, who has addressed the meeting on this subject, was an assistant on the Geological Survey for two or more seasons.

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I can see around me here some of the leading geologists of Canada who obtained a considerable part of their field experience in connection with the work of the Survey. In this list I would include Professors Miller and Brock and Dr. Parks. Our graduates, so to speak, are scattered over the whole of the civilized world and all occupy prominent positions. One has just recently gone to Australia, while my own assistant, after a couple of years' work on the Survey, is now one of the geological advisers of the Emperor of China (laughter). The Geological Survey is proud to occupy a prominent place in the affairs of the country and is anxious to fulfil its high destiny in making known the resources, and especially the mineral wealth of Canada. It invites honest criticism of its methods and the individual members are only too anxious to receive any suggestions or recommendations which will tend to raise the standard of the assistants who should be appointed.

DR. WALKER—I am quite willing to admit that a great deal of good work has been done by the Geological Survey in training students, but I think that this Institute should urge upon the Government the wisdom of making provision for the field training of a larger number of picked men.

THE PRESIDENT—If Dr. Barlow told us that his friend was chief adviser to the Emperor of Japan there might be something in it, but as he is only chief adviser to the Emperor of China it is hardly worth while mentioning (laughter). There is no doubt that a great deal of good work has been done by the Geological Survey, but I think we should point out that geological students should be afforded an opportunity of getting experience in the field. I think also we should point out that the Government, if they expect to retain the services of able men in the Geological Survey, should remunerate them better.

The resolution was put by the President and declared unanimously carried.

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Journal of the Canadian Mining Institute, Vol. VII.

SUGGESTED IMPROVEMENTS TO THE MINING LAWS IN CANADA.

By Eugene Coste, E.M., Toronto, Ont.

Toronto Meeting, March, 1904.

That wise legislation is a most powerful factor in the development of a country is such a truism that it needs no more demonstration than the counter truism that bad laws are the curse of a nation. Therefore, it behooves us of the Canadian Mining Institute, who represent the mining interests of Canada, so rapidly becoming of such importance, to consider earnestly whether our mining laws are not lacking in some essential points which, if added, would at once become such a factor for the betterment not only of the mining industries, but thereby of the best interests of the whole country.

I have in mind the two following vital points with which permit me to deal briefly before you, in the hope that it may lead first to a good discussion upon them among the mining men of the country, and ultimately to the still more rapid and permanent progress of our mining industries, which we all have at heart.

These two points are:

First.—The necessity of a continuous annual assessment work on all mineral lands in Canada, of say $5.00 per acre, failing in which these properties should revert to the Crown, unless in that case a like payment per acre was made to the Crown at the end of each year.

Second.—The great need of the enactment of a "Mines Act" by the Parliament of Canada.

To mention these needed changes and additions to our mining laws is almost to prove them to men of the mining community, such as the members of the Canadian Mining Institute, but we have also to establish our case before the legislators and the public.

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First.—Considering the first point of continuous assessment work on our mineral lands, it may be said that this principle of assessment work or of working conditions by which the purchaser or lessee is bound to spend a certain amount of labor or money on his location or claim, is well recognized by all our mining laws in the different provinces and by the mining regulations governing Dominion lands.

In order to prove this clearly it becomes necessary for us to review briefly the portions of these laws bearing on the subject:

DOMINION OF CANADA.

Quartz Claims:

Size of the claims, 1,500 x 1,500 feet=51 acres. Assessment work, $100 a year.

A certificate of improvement is due after $500 of work has been spent "on the claim itself in developing a mine."

No more assessment work is required after that, and the claim can be purchased for $1.00 an acre, and a fee of $5.00.

The patents reserve to the Crown forever whatever royalty may be imposed on the sales of the products of all mines therein, such royalty not to exceed, however, 5 per cent.

Placer Claims:

Sizes of the claims, 11½ acres, 5¾ acres, and 1½ acres, average=6 acres. Annual expenses:—

Assessment work required	$200.00
Free miners' certificate	7.50
Entry Fee	10.00
Record Fee, for certificate of assessment work being done which must be obtained before free miners' certificates and re-entry can be renewed	2.00
Total annual expenses	$219.50

Or $36.60 an acre a year.

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BRITISH COLUMBIA.

Placer Claims:

Sizes of the claims, 250 feet x 250 feet, or 1.43 acre.

Each free miner working on the claim must have a certificate. Cost $5.00 each.

The assessment work to be done on the claim is the continual work of one man during the working hours of the season. If the claim remains unworked for a period of 72 hours or more, it will be considered as abandoned and forfeited. This work cannot cost less than $350.00, and in some districts more distant from the coast it would be much more.

Leases Acquired Under Part VII. of the Act:

Sizes—80 acres, or ½ mile along the creek. Price $20.00, on application, and as much more as agreed in the lease which must be granted by the Lieutenant-Governor-in-Council.

There is a provision in these leases for the continuous working of the lease, as per the conditions therein stipulated.

There is also a tax of 25 cents an acre on all placer claims and leases, unless the owner proves that he has spent $200 a year thereon in labor and improvements.

Quartz Claims:

Size of claims, 1,500 x 1,500 feet=51 acres. Cost per year:

Free Miners' Certificate.....	$ 5.00	a yr.
Record of Certificate of work.....	2.50	"
Assessment work	100.00	"

A Crown grant can be obtained for $500, unless the claim is inside of the railway belt, when $500 more has to be paid.

If the $500 is partially paid by assessment work done, then a payment of the balance, or when the full $500 has been spent on assessment work, a certificate of improvement can be obtained, and by recording the same and paying a fee of $5.00 a Crown grant is issued. After the issuance

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of a grant, the claim is only subject to a tax of 25 cents an acre a year, which, however, is not due if work has been done on the claim of a value of $200 during that year.

ONTARIO.

(No royalties are reserved by the Crown.)

Acquisition by Purchase:

Sizes of the mining locations, 40, 80, 160, or 320 acres. An affidavit of the discovery of valuable ore or mineral on the land applied for must be made. Applications may be limited to 320 acres or less, if the Commissioner of Crown Lands so decides, in each district of a radius of 15 miles.

Prices for grants vary from $2.00 to $3.50 an acre, and for the mining rights alone the prices are one-half of the above.

All grants are made under the condition that the patentee will spend $1.00 an acre during the first two years and $1.00 an acre every year during the next five years in actual mining work on the location, or, in default, the grant may be forfeited upon an Order-in-Council of the Lieutenant-Governor being passed to that effect.

Patentees must make returns of this assessment work yearly.

Acquisition by Leases:

Ten year leases are made over locations of a size from 40 to 320 acres, on the following rentals:

First year, $1 an acre.

Each following year, 15c. to 30c. an acre, according to where the locations are.

The mining rights alone can be leased for half of the above rentals.

The same assessment work exactly is required as in the case of a grant, or the lease may be forfeited in the same manner by Order-in-Council being passed to that effect.

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Lessee may obtain patent at the end of the ten years, or as soon as all the rents and conditions as above are entirely fulfilled.

In case of iron ore, the Lieutenant-Governor-in-Council may require as assessment work that 2,000 tons a year for ten years be mined, or the grant, lease or license may be forfeited.

Acquisition by License:

A prospector may take a license. Cost, $10.00 a year. He can stake one or two locations of 40 acres in unsurveyed territory which is known to have no value for pine timber, and he may hold such locations for two years, subject to an assessment work of $3.00 an acre for the first year, and of $7.00 an acre for the second year, in actual mining work. The prospector must afterwards buy or lease the locations as in other cases.

Mining Claims in Mining Divisions:

A miner's license must be obtained. Cost, $10.00 a year. Sizes of mining claims, 990 x 990 feet, or 22½ acres, or any other size, but not more than 40 acres. The claim must be recorded.

Assessment work required.....	$150.00	a year
Yearly renewal of license.....	10.00	"
Total	$160.00	"

This amounts to an assessment work of $4.00 an acre per year on the 40 acre claim, or to an assessment work of more than $4.00 an acre per year on smaller claims.

If this assessment work is done for a period of four years when the claims are 20 chains square, or for a period of three years if the claims are only 15 chains square, or, if an equivalent assessment work is done in less time, then the licensee may obtain a certificate of full performance of the working conditions and he will then be freed from further working conditions or further payments for license, and, he may buy or lease the mineral

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claim on the same terms as provided in the other parts of the law quoted above.

QUEBEC.

Royalties:

Royalties not exceeding 3 per cent. of the net values of the ores or minerals, at the time, may be claimed by the Crown after the land has been granted, conceded or alienated for five years.

Sizes of mining concessions, 100, 200, or 400 acres. Applicant can either buy a concession or work it under a license.

Grants:

PRICES—$5 to $10 an acre for the superior metals, according to the distance from a railway.
$2 to $4 an acre for the inferior metals, according to the distance from a railway.

All mining lands are sold on the express condition that the purchaser shall commence "bona fide" the mining of the minerals therein contained, and shall spend accordingly, not less than $500.00 in the case of the superior metals, or not less than $200.00 in the case of the inferior metals. In default the Commissioner of Crown Lands may cancel the same.

Licenses:

Yearly licenses are granted on the payment of $5.00, and of an annual rental of $1.00 an acre, for areas not larger than 200 acres.

NEW BRUNSWICK.

Gold and Gold and Silver Mines:

Gold districts are divided into areas of 250 x 150 feet, called Class No. 1, and containing about 4/5 of an acre. Twenty year leases are granted of as many areas as are applied for, on payment of $2.00 an area for the first year and of 50 cents an area a year in advance after that. The

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lease is considered forfeited when this payment in advance has not been made.

It is left to the Lieutenant-Governor-in-Council by order and regulation to prescribe the assessment work required, and the Surveyor-General may cancel leases not worked or only colorably worked for five years. Royalty of 2½ per cent. reserved to the Crown, but the Lieutenant-Governor-in-Council may waive this royalty for the first ten years from the date of the lease. Quarterly returns of the work and yield are required.

Other than Gold:

A license to search and work for a term of two years over an area of 640 acres is granted for the sum of $50.00. This license can be extended to three years on payment of $25.00 more.

Within this term licensee "shall commence effective and not colorable mining operations, and shall continue the same in good faith until its termination." Leases for twenty years can then issue; these are renewable up to a full period of eighty years, and are granted for an annual rent of $50.00 for 640 acres. Quarterly returns of work and yield are required.

Royalties:

Coal, 10c. a long ton.
Copper, 4c. a unit or for each per cent in a ton of 2,352 lbs.
Lead, 2c. a unit in long ton.
Iron, 5c. a long ton.
Tin and Precious Stones, 5% of their value.
Salt, 2c. per bu., if brine is more than 15%.

The Lieutenant-Governor-in-Council may waive these royalties for five years after the issue of the lease.

Forfeiture:

Surveyor-General may cancel leases on which no work has been done for one year, or on which this work has not been efficient or continuous, or has been only colorably done.

No mere colorable working shall prevent a forfeiture.

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NOVA SCOTIA.

Gold and Gold and Silver Mines:

Gold districts are divided into areas of 250 x 150 feet, called Class No. 1, of $\frac{1}{4}$ of an acre.

Leases for 40 years are granted on payment of $2.00 an area for the first year, and of 50 cents an area in advance for each following year, on as many areas as applied for.

Thirty days' notice by registered letter is sufficient to cancel the lease if one of the payments in advance has not been made.

Assessment work of forty days' labor per area is required to be performed. This is equal to $80.00 on $\frac{1}{4}$ of an acre, or about at the rate of $100.00 an acre. The annual rental paid in advance may be refunded at the end of the year when this assessment work has been done. If this assessment work is not done annually, areas are forfeited in proportion to the assessment work unperformed. Royalty of 2 per cent. of the gross product is reserved to the Crown.

Quarterly returns of days' labors and yield of gold are required.

Other than Gold Mines:

A license to search may be granted for $30.00, accompanied by a bond of $800.00 for a term of one and a half years.

Twenty year leases are granted on payment of $50.00 on areas varying for the different minerals between 160 and 640 acres. These leases are renewable three times up to a full period of eighty years.

Annual payments in advance of $30 per 640 acres are required or the lease is forfeited after a registered letter notice of 30 days has been sent. This annual rental may be refunded if the royalty comes to more than that in any one year.

Quarterly returns of work done, royalties due, etc., are required.

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Royalties:

Coal, 10c. a long ton.
Copper, 4c. a unit, or every 1% of copper in a ton of 2,352 pounds, on ore sold or smelted.
Lead, 2c. a unit in a long ton.
Iron, 5c. a long ton.
Tin and precious stones and other minerals, 5% on their value.

From the above resume of our mining laws, it can be seen that:

In the Dominion.—On the Yukon placer claims, the assessment work required is continual from year to year—never ends by a sale of a claim—and amounts, with the other annual charges, to an annual expenditure of $36.50 per acre; while on quartz mines, which from their very nature are forcibly much slower and more difficult to open and develop, the assessment work required is only less than $2.00 per acre per year, and that for only five years, after which a full-fledged certificate of improvement that sufficient has been spent, in the language of the regulation, "on the claim itself, in developing a mine," is granted, and no more assessment work is afterwards necessary. Just fancy a mine developed with an expenditure of $500 only, and a quartz mine at that!

Who can understand also the logic of the legislator, who requires the placer miner to keep working his claim continuously at a rate per year of $36.60 per acre, while he frees the quartz miner from all further responsibilities in regard to working his location after he has spent only $2.00 per year, per acre, for five years. To us, the quartz mine is the one which, requiring by far the most work to be done on it before it can become valuable to the purchaser and to the country, should be the mine on which the law should compel continuous assessment work year after year.

In British Columbia.—We have the same anomalies in regard to the work to be done in placer mining as against the work to be done in quartz mining. But it is here much more accentuated as the placer miner has to continuously work his claim during the whole of the working season, which costs him from $350.00 to $700.00 a year, according to the district, on a claim of only one

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and one-half acre, whilst the quartz miner gets relieved also in this province, of all working conditions after spending only $2.00 an acre per year for five years, after which he gets his grant, and is only subject to an annual tax of 25 cents per acre. Surely the law does not impose on the owner of quartz claim his due share of the burden of opening up the mines of the province, and it is no wonder that the mining men of British Columbia composing the Provincial Mining Association, at their last meeting, held lately at Kamloops, unanimously adopted the following resolution:

"In view of the embarrassed state of the finances of the Province, and the objections which have been raised upon this ground towards measures for the relief of the mining industry, and the fact that all demands for such relief during the past two years have been met with a counter demand on the part of the government then in power, for a substitute whereby the revenues of the Province will not suffer loss;

"Be it therefore resolved that this association desires to reassert that it has no wish to be relieved at the expense of other industries, but on the contrary, is now, and always has been, ready to pay its fair and equitable share of the taxation necessary for the economical and business-like conduct of provincial affairs.

"In the opinion of this association, the natural resources of the Province, and not the industry, should bear the burden of taxation. The enormous area of valuable land now held under a taxation which is practically insignificant, should be made to pay its proper share of the burden and thus relieve industry.

"The association, therefore, respectfully recommends to the government, the advisability of enquiring into and adopting the Australasian, or some other equitable or uniform system of taxation on land, including mining lands, that will tend to increase the revenue, to the further settlement of the lands of the Province, and to encourage the development of its great mineral and other resources.

"In view of the vast areas of land held in this Province it is believed that the revenues from such a system of taxation will more than meet the annual deficit of the Province, and will enable it to materially relieve the mining industry."

Two main points will be noticed in the above resolution; first, that vast valuable mineral lands are now held in the province under an insignificant taxation; second, that in the opinion of the British Columbia mining men a fair taxation on idle mineral lands would tend to encourage the development of its great mineral and other resources. We hope to make this point quite clear in our subsequent remarks.

With regard to placer leases in British Columbia, obtained

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under Part 7 of the Act, and also as regards coal leases dealt with in a special Act, the law says that assessment work on these must be continual, but it does not define this work any further, in a general way leaving it to each lease. After five years the coal lessee may purchase and is then relieved of any further assessment work.

In Ontario.—Even after the patent of the mineral land is granted, temporary assessment work is required, but only for a few years; and the Act says that this work must be done under pain of forfeiture of the patent.

But this assessment work is too small, and even this small work is not insisted upon in practice, and, notwithstanding that hundreds of patentees failed to comply with the law in that respect during the last three years, only 28 cancellations of patents were made by Order-in-Council during that time, cancelling altogether some 3,300 acres only.

The extent to which we thus part with our mineral lands in Ontario, without getting any actual work done towards the development of our mines is simply enormous, and the evil consequences of this wrong policy on the best mining interests of the province are really frightful to contemplate. Some may think that we exaggerate, but a few official figures will show that we are only recording a cold unpleasant truth.

In the years from 1897-1902 (inclusive), the reports of the Bureau of Mines of Ontario, give, as having been granted by a full purchase or lease during these six years, 3,922 locations of a total acreage of 411,190 acres. Now, what is the proportion of that large acreage (taken up in our most newly discovered mining districts) which is actually being worked and productive, even to a small extent? Referring to the last official report of the Bureau of Mines for 1903, we find that just about 100 places or mines were working in the province in 1902. These workings, with a few exceptions, covered in each case only a very few acres, but we will say that in the average 40 acres at each place were being developed, which is certainly a very liberal estimate for the average. We then have 100 x 40, or 4,000 acres, as being under min-

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ing work in the whole of the province in 1902, or not 1 per cent. of what was granted in the last six years alone. If we now take into consideration all the mineral lands that were granted in Ontario before 1897, and assume that they amount to another 400,000 acres (which certainly must be a low estimate) we see that only one-half of one per cent. of our acquired mineral lands are being developed. If we now consider the well-known fact that the area covered by the good mines in all good and old mining districts, is quite a small percentage of the total area of that district—say 5 per cent. to 10 per cent. at most—and if we apply this approximate percentage to the one two-hundredth part of our acquired mineral lands which alone is being worked, we see that the probabilities for the good mines being in the idle and unworked areas are as several thousand is to one. In other words, in the present conditions of Ontario, the mining community of the province actually working the mines in a bona fide manner, have less than one chance in several thousand to develop a good mine from lands acquired directly from the Crown, so much of it being locked up that almost all the good mines must be in that idle portion. *Idle granted mineral lands are then not only useless but fatal to the development of our mines.* Is it to be wondered at then, that we have so few good mines in Ontario today? The wonder is, on the contrary, that there should be any mining men left willing to risk their money and run the chances against such terribly large odds.

But some will argue that it will be all the better to have all the mineral lands of Ontario passed out of the ownership of the Crown in the hands of private owners, as the self-interest of these owners can be relied on to ensure the working and development of the land, if they are worth it, as soon as possible. This argument might be advanced with some force if the value of these lands was not entirely unknown and to be demonstrated by the expenditure of much money, and if we had not the past experience of the last six years quoted above, which absolutely condemns it, and which proves beyond peradventure that the present owners of mineral lands in Ontario do not develop and work these lands under the conditions of the existing law which gives these

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lands away without sufficient guarantee of work on them. No amount of argument will alter that most palpable fact, unpleasant as it may be.

What is to be done to remedy this most unsatisfactory state of affairs? As we cannot expect to change the human nature of the people who will keep buying for a song, if they can, from the Crown, what they dream as prospective rich mines, whether they intend to work them or not, we must change the law, in order that through an assessment work to be performed year after year under penalty of forfeiture, this tying up in idleness of thousands of acres of mineral lands will become impossible. I would suggest an annual assessment work similar to the one now in force on the claims of the Michipicoten mining division, which amounts to $4.00 or $5.00 per acre. Failure to comply with this annual assessment work to cancel and forfeit the mineral lands back to the Crown, unless in that case the same amount per acre was paid to the Crown within, say, one month after the end of the year. In the Yukon Territory a similar payment (of $200.00 per year on a claim only 6 acres in extent in the average), in lieu of assessment work is not accepted any more, since the first of August, 1903, as decided by an Order-in-Council of the thirty-first March, 1902; and, evidently, this last point of a cash payment in lieu of assessment work is one very open to discussion. If the cash payments were accepted when the assessment work was not performed, these payments might very properly form a special fund to be devoted by our Governments to the betterment of our mining industries. In the case of a new discovery, when the discoverer very properly gets a free location for his discovery, according to the present law, I would suggest that the same working conditions be included in the grant, but with the proviso that the discoverer would retain a 15 year patent right (of, say, 4 or 5 per cent. of the net profits to be derived from the location) in case he forfeits the location on account of failure to comply with the working conditions within 15 years from the date of the grant.

In Quebec.—(To continue our analysis of the above resume of the mining laws). We have a very similar condition to the

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one in Ontario in regard to the assessment work to be performed on the mining concessions. The law affirms that "all mining lands are sold on the express condition that the purchaser shall commence bona fide the mining of the minerals therein contained, and shall spend accordingly not less than $500.00, if for superior metals, and not less than $200.00 if for inferior metals. In default the Commissioner of Crown Lands may cancel the sale."

The second part of this express condition in which the insignificant amounts of $200.00 and $500.00 are mentioned to be spent towards the bona fide mining of the minerals, in concessions of 100 to 400 acres in extent, spoils all the good intended by the first part of the express condition of the law, as evidently these amounts are hardly sufficient to scratch one acre of it. Therefore, we mean no disrespect to our Quebec legislators when we say that they must have made some mistake when they mentioned these small amounts of assessment work, which would be laughable if they were not so injurious to the best mining interests of the Province of Quebec.

Then, again, the last part of the express condition directing the Commissioner of Crown Lands to cancel the sale is not any better enforced in Quebec than it is in Ontario.

In New Brunswick and Nova Scotia.—We can review together the mining laws of these two provinces, as they are very similar, as shown in the above resume. The principle of a continual annual assessment work is so well recognized by the mining laws of both of these provinces, that the mining property is there never sold by the Crown, but is simply always leased. In the case of gold and silver mines the annual assessment work in Nova Scotia is 40 days' labor per area of 4/5 of an acre, or at the rate of about $100.00 per acre, per year. This is twenty times as much as the rate we propose, as above, of $5.00 per acre. In New Brunswick it is left to the Lieutenant-Governor-in-Council to prescribe the amount of assessment work by order and regulation.

In the case of other mines than gold and silver mines it is expressly stated in the New Brunswick law that the licensee having obtained a license to search for two or three years "shall com-

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mence effective and not colorable mining operations, and shall continue the same in good faith until its termination," when he may acquire a lease, and then "the Surveyor-General may cancel leases on which no work has been done for one year, or on which this work has not been efficient or continuous, or has been only colorably done; no mere colorable working shall prevent a forfeiture." A similar clause (Sec. 122) is inserted in the Nova Scotia law, though Sec. 108 says that if the annual rental which is to be paid in advance on the lease is paid, then the lease will not be liable to forfeiture. As this annual rental is only $30.00 for areas of 640 acres, or about 5 cents an acre only, this ridiculously low payment defeats the object of the law in regard to enforcing work, and under that clause great monopolies exist in the province in regard to coal mining, such as the Dominion Coal Co., who holds 175 square miles, or 112,000 acres; and the Cumberland Railway and Coal Co., who owns over 200 square miles—128,000 acres—and mine only about 400,000 tons a year, or less than 4 tons to the acre.

As we have seen, the recognition of the principle of assessment work on our mineral lands is universal in the mining laws of the different parts of Canada. That is the strongest proof that could be adduced of the wisdom of the policy of enforcing such a working condition which has evidently and naturally been found to be necessary to ensure the development of the mines. But unfortunately it is illogically prescribed in our laws—often in a half-hearted and indifferent manner—for altogether too short a period and for too small an amount, whilst at other times (like in the placer claims of British Columbia) the terms of this working condition are altogether too exacting; or it is altogether too indefinite, and not lived up to, as is especially the case in Ontario, Quebec, New Brunswick and Nova Scotia.

In conclusion, we repeat the suggestion we have made above that in all our mining laws a fair annual assessment work of say $5.00 per acre should be exacted and to be continually done year after year on all our mineral lands, with the express understanding that a failure to perform this work would mean the forfeiture

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of the land unless in such a case the same amount per acre was paid to the Crown within one month after the end of the year in which the assessment work would be unperformed. The only exception to a complete forfeiture of the land in case of non-performance of the assessment work should be: first, in the case of a free grant to a discoverer, when I would suggest the proviso mentioned above of a 15 years' patent right to the discoverer; and, second, in the case of locations on which the work performed in any previous year or years had been greater than the assessment work required, this extra work should be made "cumulative" and to apply to subsequent years in which the assessment work would not be performed.

Far from being a hardship on the mining community, who actually works bona fide the mineral lands, this system, if rigidly enforced, would be one of the greatest boons that could be conferred on this community and on the whole country, as it would effectively eliminate all the drones in the hive (to use what is, perhaps, too forcible an illustration, but we mean no offence to any one) and the mineral lands of the country would be at all times open to the bees to work, and it would not be long before the honey would be overflowing from the many rich mining districts of Canada, at last developed and thriving.

Second.—It will not be necessary for us to say very much upon the second point of this paper, as set forth in the introduction, viz.: the necessity of the enactment of a mining law by the Dominion Parliament.

It will, we think, be quite sufficient to remind our legislators at Ottawa, respectfully but firmly, that they have so far neglected this important duty, and that for years now they have allowed most important mining districts, like the Yukon Territory and some of the coal districts of Alberta, to be simply governed by regulations approved by Order-in-Council.

We respectfully submit that, except for a temporary period, this is not as it should be, and that the people, through their representatives in Parliament, should have a voice in questions so vital as royalties and taxations of mines, for instance, and

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should have also the great benefits conferred by a stable law duly enacted after all the necessary readings of it have taken place before the House and the Senate, instead of being governed by regulations which are liable to be changed (and have often been changed) suddenly, and which, from the very nature of their preparation by a few officials of the Government only, are of necessity not as mature as an Act of Parliament would be.

NOTE BY THE SECRETARY.—Comments, criticisms or discussions upon all papers are earnestly invited and will be promptly published as soon as accepted by the publication committee.

DISCUSSION.

MAJOR LECKIE—I have had much pleasure in listening to the remarks of my friend Mr. Coste, and I think he is exactly on the right track when he says that the development of our mineral resources in this and other provinces lies in setting free, as far as possible, the coal areas and mining locations which are held by individuals and corporations who are not really working and developing these minerals. The taxation ought to rest, as Mr. Coste says, upon locations held by speculators, by claim jumpers, and these kind of people who will not put a shilling into development. For instance, we have companies and corporations who are spending thousands of dollars a year in developing locations held by them, while on the other hand we have men holding areas and locations who do not spend a shilling in the way of development, but who wait to profit by the expenditure of others and then sell their claims. These are the men who ought to be taxed and compelled to spend a certain amount of money every year in the development of their claims; not in the way of paying so much an acre, but in the way of absolute work. In Australia until recently, this thing went on, as it does in Canada, but now it is simply compulsory that mining properties should be worked. If we do that in Ontario; if we tax the man who holds areas and does nothing, we will have more development of the mineral resources of the province.

MR. THOMPSON—If there is one thing that will bring a

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British Columbia mining man to his feet it is a discussion on mining laws. We often say in British Columbia, that when you want to hear a good hot speech after dinner where mining men are assembled, you want to get them to talk about mining laws. We are cursed in British Columbia with the worst mining laws in this broad Dominion. Our esteemed President has given us a brief review of the conditions governing the location and acquiring of mineral claims in the province of British Columbia. From 1894 to 1896 it was said that British Columbia had the best set of mining laws on the American continent, but from 1896 to the present time we have had so many governments that we cannot keep track of them, and each successive government has tampered with the law to such an extent that to-day we have the worst mining laws. To-day locators, or I might say speculators, can acquire a claim for a very small fraction from an original prospector, and they will at once form a company with capitalization ranging into the millions—nothing less than a million is big enough for them—and then they start out to fool the people in Eastern Canada, Montreal and Toronto contributing their mite. After they get through with all this, in fifty per cent. of the cases it is found that they never had any right to the mineral claim which they said they owned, and which comprised the so-called mine; and in ninety-nine per cent. of the remainder, there was nothing that could be called a claim at all. In some cases they produce beautiful specimens of diorite and fool people into believing that it is a valuable mineral. There is one thing which the President did not point out, and which has a very important bearing upon Major Leckie's remarks; that is, that it is not compulsory for the owner of a mineral claim previous to getting a Crown grant to spend $500 in five years. At the present time the owner of a mineral claim can hand over to the Government the sum of $100 a year, and he need not necessarily do any work at all, and after he has paid to the Government $500 or spent $500 upon a mineral claim, which in the majority of cases he has not spent for development but simply for the purpose of killing time, they get Crown grants to mineral claims, and after that a payment of 25 cents per acre per year will keep the title good.

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That is very unfair, because it allows a man to locate a mineral claim, and when he happens to hold a mineral claim adjoining real working properties to sit down and watch in comfort the development which is done by hard earned money on the adjoining claim. That is done in the Rossland camp; it is done in the Boundary camp to a large extent; it is done in every camp in British Columbia and it is decidedly unfair. There are hundreds of claims in British Columbia in that position.

I believe that our legislators in Canada, both local and federal, are altogether too ignorant of the mineral resources of this magnificent country. You ask nine-tenths of the members of the House of Commons at Ottawa what they know about the mineral resources of the Dominion, and they will probably tell you: "There are some mines in British Columbia, and there are a few in Ontario, and of course there are one or two in Quebec and Nova Scotia, but I really do not know whether they are gold mines or what." We had two deputations from the House of Commons last year out in the west, one of Conservative members and one of Liberal members, and these gentlemen expressed surprise at the work they had seen along the railway as they went through the country. They thought it was a marvellous thing, but they went back to the House of Commons and they have not been heard of since. For their information I would like to get more statistics regarding the possibility of this industry in this great Dominion of ours. I have had experience in Mexico, in the United States and in Canada. As you all know, the mining districts in British Columbia are an extension of the Rocky Mountain ranges south easterly through the United States into Mexico, and on into these fighting little nations in South America, a total length of 10,000 miles. The Dominion of Canada alone possesses some 1,600 miles of this mineral territory for an average width of 600 miles; the United States possesses 1,300 miles, and Mexico approximately 1,700 miles. Mexico has produced from the 1,700 miles $5,500,000,000 up to the beginning of the year 1903, which is equivalent to about $3,150,000 per lineal mile; the United States has produced from her 1,300 miles lineal, something like $4,500,000,000 which is equivalent to $3,500,000 per lineal mile, while the

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Dominion of Canada has produced about $166,000,000 up to 1903, which is equivalent to about $100,000 per lineal mile. That is not much to be proud of. The mineral ranges in British Columbia are just as valuable as the Rocky Mountains in the United States and Mexico, and yet we have had the above poor result. I have travelled this territory from one end to the other, and I cannot see for the life of me why the Rocky Mountain region within the Dominion should not be quite as valuable as that in the United States and Mexico. Last year the production both in the United States and in Mexico showed an immense increase over the previous year, but in the Province of British Columbia our production last year decreased very materially. I believe that the total product of British Columbia last year was in the vicinity of about $20,000,000, while it should have been at least five times that amount. It seems to me from the splendid papers that have been read at this meeting, that the Rocky Mountain ranges only possess after all a small portion of the mineral wealth of this Dominion. We have in the beautiful Province of Ontario certainly very large mineral deposits and you have a very large country yet to explore; Quebec has its share of mineral resources and Nova Scotia and New Brunswick theirs. Look at the enormous possibilities, and we can easily see what a field there is to encourage young men to the study of mining engineering. Every one of the students to-day will be needed and a good many more will be needed too. If we are to tax mining enterprise out of existence what is to become of the industry? From the Atlantic to the Pacific we should have as favorable mining laws as the Government can devise. I will close by saying that I am absolutely in accord with what Mr. Coste has said. Both the Federal and the Provincial Governments should be wakened up to the fact that they have a country containing mineral resources of the greatest magnitude, resources second to none to any country in the world, and that they should pay attention to the development of the industry and have mining laws passed that will enable practiced men to engage in this great enterprise (applause).

MR. CLARK—There are so many practical men present that I do not care to take up much of your time, especially as my views

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on the legal aspect of the questions discussed were presented to the Institute in a paper which I read a few years ago, and which was discussed to some extent at that time. I think the principle is one which is not capable of any adverse argument at all; namely, that it is the mine that is worked that should be encouraged. That is the essence of Mr. Coste's paper. Of course, in connection with the working out of any scheme to accomplish this object a great many details have to be considered because we cannot start from the beginning now as very large quantities of land have been already granted by the Crown, and vested interests created, and all these have to be taken into consideration in considering the difficulty. The rights of prospectors should also be carefully safeguarded; but I think that there can be no question whatever in regard to the general principle that the policy of the Government in respect to mining lands should be to encourage actual mining, and that a man should not be taxed because he works a mine rather than keep it idle. As to the question of mining regulations there is of course a great deal to be said in the case of such a district as the Yukon, where new conditions arose. It is probably necessary in the initial stages of mining development in new districts that matters should be dealt with in a temporary way without the solemnity and formality of statute law. But I quite agree with Mr. Coste that the time has come when the laws in regard to these territories controlled by the Dominion should be put into statutory form, so that mining men will know exactly what they will have to expect. The importance of certainty and stability in the mining laws cannot be over estimated.

MR. HARDMAN—I may say that Mr. Clark has voiced my views exactly.

MR. D. O'CONNOR—I cannot agree with Mr. Coste as to the expenditure of $5 per acre, as I consider it is a hardship on the prospector. I know where 160 acres cost $228 and if the owner had to pay $5 per acre on it, it would mean $800 more, which would be very harsh on the prospector, considering that the land turned out to be worth nothing. It is all very well to talk of making the speculators pay $5 per acre, but when it comes to the poor prospector it is a different matter altogether.

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MR. GIBSON—I do not agree with Mr. Coste's suggestions. I think it is a visionary idea to suppose that by compelling a miner to perform $5 worth of work per acre per year you are going to compel him to make a mine out of his claim. If you force him to spend money against his will he will expend it in the easiest way possible for himself, with little reference to whether it does his property any good or not. In the city of Rossland and elsewhere men have been known to dig holes in the streets under guise of doing assessment work, and in the Western States, where a man does not wish to show up his claim but has to do so much labor in order to hold it, he is as likely as not to open a shaft on the side of the hill where he knows there is no mineral, just because if he does not do so many dollars' worth of work on it somewhere someone else will jump it. What do men go into the mining business for? Is it not to make money? And what more powerful incentive can there be to work a valuable deposit, or to get someone else to work it, than the desire to convert that latent value into cash? An idle gold mine or an iron ore deposit in a state of nature is not a source of revenue, and it may be taken as an axiom that if a man has a good thing he will find some means of putting it to use. It is in his interest to do so, and that is a more compelling power than any law can bring to bear. If it is not in my interest to spend money in opening up my mining property, I will not spend it, and why should I be forced to do so? On the other hand, if it is in my interest, I need no compulsion. The law now requires the expenditure of a certain amount of money before an unqualified title can be got from the Crown, not, as I understand it, with the object of compelling the owner to convert his claim into a mine, which might take many thousands of dollars, but to ascertain whether there is mineral or not and to show his bona fides so as to discourage the taking up and holding of lands for mere speculation. Why should we not make the path of the miner or mine owner as comfortable as we can, and allow him to have freedom of action in handling his own property, just as we allow everyone else to handle his own property according to his own ideas? We do not oblige a farmer to spend so much per acre on his farm——

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MAJOR LECKIE—But you make him clear so much every year.

MR. GIBSON—That was entirely analogous to the conditions in regard to mining property. We do not oblige a farmer to do that after he gets his patent.

MAJOR LECKIE—You do.

MR. GIBSON—Major Leckie is under a misapprehension. The duty required of a settler in taking up agricultural land is that he shall clear so many acres, put up a house and live so long on his place, having done which he gets a patent from the Crown, and the Crown has nothing more to say. Why make a difference between the farmer and the miner?

MAJOR LECKIE—Let the prospector do the same thing.

MR. GIBSON—That is the law in the Province of Ontario, and I am surprised that Major Leckie does not seem to know it. The law requires that a man who takes up mining land shall spend a dollar an acre during the first two years in developing it and one dollar per acre for the next five years, or he may do that work if he likes in a shorter period. After paying the fees that the Crown requires, and which it is only right he should pay, he gets his deed and the Crown has no more to say to that man in regard to that property. He can do what he wishes with it after that. If you oblige him to still continue spending money on his land under penalty of forfeiting it you may cause him to drop the property, you may change owners, but what guarantee have you that the new owner will do anything more? The Crown may get a few dollars by selling the land over again, but it is doubtful whether the country would get any more mines. To make a mine out of a claim involves the expenditure sometimes of thousands, sometimes of tens of thousands of dollars. It would be absurd to pass a general law requiring people to expend whatever amount might be necessary to convert a claim into a mine, yet anything short of this would not give the result which Mr. Coste aims at. I do not make the mining laws, and I am not responsible for them, but I wish to make this explanation because I think there is a misapprehension in regard to what the law really is. I am sorry that I cannot agree with our President on this occasion, as I generally do agree with him, because he is a

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man of ability and common sense, but in this matter he has taken a position contrary to the laws of the Province of British Columbia, of Ontario, of Quebec, of Nova Scotia, of New Brunswick and of the Dominion of Canada. The members of the Provincial Legislatures and the Dominion Parliament are sent there by the people to make laws in the best interests of the country, and the mining laws in all parts of Canada have been arrived at after the fullest discussion and the most long-continued and careful consideration. Is this Institute now to say that these bodies are all mistaken, and that we are the only people who know how to make mining laws in this country?

THE PRESIDENT—A few words in answer. The last point that Mr. Gibson made is just the point that is going to prove against him. Some Legislatures may have lost sight of the fact that mineral lands to be valuable to the country must be worked, but in British Columbia it is different, and a man has to stay on his claim the whole of the working season. He cannot be away from that claim 72 hours in succession. In the Yukon the Dominion Government requires a man to spend at least $200 a year on his claim. They will not accept the money, but they will force him to expend it in labor on his claim since August, 1903. He cannot get a title to his claim and keep it unless he has done the work annually. In Nova Scotia a man has to spend every year money on his claim or else it will be forfeited back to the Crown, and the same is true in almost every province as I have reviewed in the paper. That is a sufficient answer to Mr. Gibson, when he says I have taken a position contrary to the laws of Canada. In the last six years there have been 411,000 acres of land sold in Ontario, but there are only 4,000 acres worked. What more proof is needed to show that the self-interest of men, on which Mr. Gibson relies so much for the development of our mines, is not at all sufficient, in fact is often just the reverse and selfishness and greediness of man is much to be feared in this matter. We mining men want to see our mineral resources developed, and the mining laws of Ontario, and of all the other provinces of the Dominion, as at present in force, have just the contrary effect, because they do not apply rigidly the principle which they recognize of compel-

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ling work to be done on granted mineral lands. This work, of course, is not suggested with the idea of compelling one to make a mine out of his claim, as Mr. Gibson puts it, but with the idea of preventing this immense tying up of enormous areas of mineral lands, the statistics of which I have given in the paper.

MR. JAMES WALSH, Port Arthur—I oppose the suggestions made by Mr. Coste as unfair to the prospector. I hold that the prospector is the pioneer in mining work, and that he is entitled to encouragement rather than taxation from the Government.

MR. ANTHONY BLUM—The mineral resources of Canada are as varying in character as their distribution and quantity are extensive. Universal annual assessment work requirements for Canada would depress development in some districts as it would stimulate development in other districts.

While compulsory annual assessment work, imposed upon alluvial deposits and placer claims, may be beneficial to the prospector, mine owner and the Government, and quicken their development, such idle claims might force energetic, able miners who would work them, out of the district and thus deprive the laboring man of work, the merchant of business and the country of gold.

Placer mining in some cases may be profitably carried on by a single man with pick and shovel and a few sluices, and two men may work together advantageously, with an additional windlass, rope and bucket, and they can, at the close of their day's work, gather gold (the fruit of their labor) and exchange it for grub, money and their every want.

I beg, however, to differ with the views of our esteemed President as to enforced annual assessment work in Ontario, which I believe would be a useless burden upon the prospector, mine owner, and alike injurious to the mining industry and the Government.

In Ontario minerals exist in seams, veins, lodes, deposits, etc., embedded in hard rock, drilling and blasting being necessary, and where no returns can be expected until after the expenditure of tens of thousands of dollars for machinery, supplies, labor, etc., and many months and even years of time.

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In the United States, where annual assessment work is required, it appears to me, on other than placer claims, annual assessment work stimulates claim jumping, by men who generally have no intention of doing development work or honest mining, and whose sole object is to extort money from the owner. During over twenty-five years' operations as miner and mine owner in Montana, Arizona, Colorado and other states, only a few instances of pecuniary benefit to the prospector or the mining industry have come to my notice from assessment work.

During the past nine years as miner and mine owner in Ontario and recently also in Manitoba, I can only recall a few instances where work, outside the original discovery, such as shaft sinking, etc., by the prospector, has been of any benefit to himself, to the district or the Government.

The prospector usually is a poor man, has no moneyed associates and such pits and holes his means admit of sinking, do not explore the mineral deposit. Generally such work is done in the wrong way and at the wrong place and is useless for practical mining operations. The greatest curse to the mining industry is the waste of money on unprofitable claims and work done under inexperienced direction.

The only conditions I would impose upon the prospector or discoverer of mineral in Ontario and Manitoba are that he locate and trace the outcroppings of the vein, mineral, etc., chop out the timber and brush along the lode line, uncover and strip the vein or deposit and remove the vegetation, earth, loose rocks, etc., and if values are disclosed, blast or cut out a trench from two to four feet wide and from four to six feet deep across the vein or deposit as the case may be. If there are any values on his claim, his ambition for gain will cause exertion to the best of his ability and means, and it is waste of energy and capital to compel the prospector to perform work against his will.

A mining claim in Ontario is much more desirable to the practical miner and capitalist with only such work done as described in the foregoing paragraph, than to have the claim punctured with holes and pits which are dangerous to life and an emblem of misdirected labor and capital.

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I would never ask the prospector in Ontario to sink a shaft requiring a windlass, or do any work which one man alone could not do.

We should not compare the acreage of a placer mining claim of other districts with the prospector's acreage in Ontario. A single placer claim may provide more work than any one man can do and it would be unfair to allow men to control greater areas then they can work, and deprive, maybe, hundreds of men who have travelled long distances and staked their all on the acquisition of a claim. Therefore it is best to make placer claims small and insist on development, in order that work will be done while the rush is on.

In Ontario, often among scores of locations, there is not one which justifies development. In new mining regions large acreage is necessary to owners of property under development, to control wood supply for fuel, etc., and if a profitable producer is developed, and the ore deposit extends onto adjoining property, it will not be long before such property is also brought under development.

The production of placer mining claims generally are of limited duration. A strong constitution, pick, shovel, pan and necessary energy only are needed, while quartz and rock mining is an industry requiring large capital, skillful management and long time to bring into successful operation.

The Ontario Government is to be congratulated in having leased and sold such large areas of mining land and I would strongly advocate continuance of the same liberal policy as in the past, as there remains unsold and undeveloped such vast areas of promising mineral lands, which compared with the acreage sold, would appear that Ontario's almost limitless mineral resources were only beginning to be recognized.

Should the Ontario Government enforce its present assessment work requirements, it would cause irreparable injury to the prospector, mine owner and the mining industry. There may be some cases where valuable mineral deposits remain undeveloped and are withheld from sale, and for which some compulsory assessment work may be desirable. I am confident that a universal

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assessment law to reach owners of such mining claims would cause injury to other owners of mining claims, and while I would like to see some law enacted which would bring in to market such valuable mining claims, we should, however, have care that, while forcing such claims onto market, we de not deprive the prospector and poor miner of his claims and thus banish from the province with great loss to themselves, these sturdy men upon whom the development and growth of the mining industry are dependent.

THE PRESIDENT—Since over 400,000 acres of mineral lands in Ontario alone, have been locked up within the last six years, it is quite evident that the country has not had the best of it, and that it is imperative for us to enact new laws to stop this suicidal wiping out of our mineral resources. Prospectors, of course, should be encouraged, but our mineral lands should be at all times open to the work of bona fide mining men, which should not be hampered by the greed and ignorance of speculators.

MR. CRAIG—Take the case of the prospector; no doubt he gets little return for his work. I think the Ontario Mines Act has been blamed for more than it deserves; but there is a great defect in it owing to it allowing mining lands to be taken up and remain undeveloped for fifty years. That system should be abolished altogether. I believe that Mr. Coste's suggestion, in a modified form, ought to be adopted, and that if it were it would help not only the mining men but also the prospector. My idea is that a prospector should be allowed to take up a limited amount of land without paying anything; the compensation to the Crown being the fact that he discovered it. However, I would not let any man hold, say ten square miles of mineral land year after year and do no work. I do not blame the Government, because I believe that they have tried to do their best, but I do believe that a tax should be placed on any large area of undeveloped land so that if it be not developed it will be forced back into the hands of the Crown.

MAJOR LECKIE—For forty-four years I have been working in Nova Scotia, New Brunswick, Quebec, Ontario and part of the Northwest, and in most provinces the law recognizes that you are compelled to develop and do a certain amount of work on your mineral areas. In other countries the same thing obtains.

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This is not a provincial Institute, but one embracing the whole Dominion, from ocean to ocean. Mr. Gibson spoke from the standpoint of our provincial administrator. The mining laws of Ontario are liberal and are administered in a liberal and intelligent spirit. Practically we have not much to complain of, but in a general way the mining industry would benefit by a friendly consideration of the points advanced in the President's paper.

MR. THOMPSON—During the year 1903, in the Republic of Mexico, $20,000,000 capital went from New York alone, and I venture to remark that more capital went into the mines of Mexico during that year than into the United States and Canada combined. That is not because Mexico is a better country for mining, but it is because they have favorable mining laws. Before a prospector can even prospect in Mexico he must go to the Government and pay a tax for the pleasure of prospecting, and after he has located his claim he must every three months pay the sum of $2.50 per claim or else it reverts to the Government. You will remember the sale of the Centre Star mine in your city to a company for $2,500,000. Mining engineers in Rossland who are familiar with the situation know that the Le Roi-Centre Star vein extends in an easterly direction across two other claims. These claims are to-day held at a price of $1,000,000 and cannot be purchased for less, notwithstanding the fact that they are idle and undeveloped. Why in the name of common sense should there not be a reasonable tax on these claims if they are worth $1,000,000?

MR. CLARK—Mr. Craig's suggestion has been already carried out in the Ontario Law, in which it is provided that the prospector is entitled to a claim of forty acres where the discovery is five miles from the nearest known mineral deposit.

MR. CRAIG—I think that regulation does not amount to much. I think the Ontario Government has been perhaps a little too eager to increase its revenue, and thus has brought about a condition that thoughtful men are beginning to view with alarm.

In the United States it is well recognized that if there be a rush to any district and it receives a set-back it will later on be

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almost impossible to straighten up the titles. As a result of this, mining in such a district is severely impeded.

A similar state of affairs is gradually springing up over almost every mining district in Ontario. The Ontario Government has been too eager to sell the lands on account of the revenue realized from them. As Mr. Coste has stated, there is already a very extensive area of mining lands taken up and the titles to these are gradually becoming more and more complicated. No mining man will spend a couple of years trying to straighten out a title when he can go elsewhere and make an immediate investment. If the Ontario Government does not change its policy the whole mineral area will in time be tied up and there will be great danger of the mining industry languishing. I think that undoubtedly some modified form of Mr. Coste's idea should be adopted. It is only now that the attention of the Ontario Government has been called to this state of affairs. After they have given the matter due consideration I am sure they will second the idea instead of opposing it.

THE PRESIDENT—Allow me to say that it was far from my idea to persecute the poor prospector. I have met some of these prospectors in the woods myself, and I know that they render very valuable services to the country and to the mining community, and I would be the last one to want that any harm should be done to them. But I draw a distinction between the prospectors and the men who hold mineral lands for speculation and do not work them, and who thereby prevent bona fide mining men from spending the money on our mineral lands which it is absolutely necessary to spend before many of our mineral recources can be shown to their true worth and value. Mineral resources are hidden under thousands of tons of rocks and thousands of feet of strata often, and only the expenditure of much money, very often, will bring them out. If the poor prospector cannot do this expensive work it will be found in my paper that under my suggestions his discovery claim is recognized nevertheless. As to the pure speculator, we don't want him at all, and such an annual assessment work as I suggest in this paper would eliminate him altogether, to the best interests of the country.

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Journal of the Canadian Mining Institute, Vol. VII.

ACID MAKING FROM PYRRHOTITE.

By Ernst A. Sjöstedt, Sault Ste. Marie, Ontario.

Toronto Meeting, March, 1904.

Attempts at using pyrrhotite (monosulphide of iron, $Fe_6 S_7$) instead of brimstone or pyrite (bisulphide of iron, $Fe S_2$) for acid making have often been made, but the same having repeatedly ended in failure and disappointments, they finally came to be considered as useless and foolhardy undertakings; and some engineers and professional men have even gone so far as to publicly pronounce it an impossibility, as will be seen from the following quotation:

"One of the most serious errors ever perpetrated in the manufacture of acid from pyrites is the attempted employment of pyrrhotite for pyrite. Aside from the greatly lessened proportion of sulphur, 36% as against 53%, the pyrrhotite will not even yield freely what sulphur it contains, but crusts with oxide of iron, turns black, and is soon extinguished when treated in a ordinary pyrite kiln. It seems scarcely possible that extensive works for the manufacture of acid should have been erected, their supply being entirely derived from a deposit of the valueless monosulphide, but such has been the case in more than one instance, and will continue to be so in enterprises conducted without skilled direction."

When, therefore, a few years ago the problem was presented to us of treating the Sudbury pyrrhotite so as to recover not only the nickel, cobalt and copper present, but to utilize its sulphur and iron contents as well, no sympathetic co-operation was to be expected, and open criticism was heard from many quarters. It is with a feeling of no small amount of satisfaction, therefore, that we now are able to announce that the question of economically using the sulphur from said ore has been solved; and take pleasure in herewith presenting such information and data as will prove to the engineering fraternity the value of the work done, and the importance of the results obtained.

THE PROBLEM.

The Sudbury pyrrhotite, as shipped for smelting purposes,

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averages about 15-20 per cent. sulphur, 1-3 per cent. nickel and .5-2 per cent. copper, the balance being made up of iron and gangue. Realizing the impracticability of using such low grade ore for the purpose set forth, the first step taken was in the direction of concentrating it. The pyrrhotite being easily distinguished by its pale color from the deep yellow chalcopyrite, the separation of the same from the copper ore and the gangue was readily accomplished in the rock house, at the crusher and on the sorting table; and in this separation we obtained two workable grades of ore, one high in copper and gangue and low in sulphur, designed for the ordinary matte smelting process, and the other, low in copper and gangue but high in sulphur and nickel, intended for the acid plant. This latter grade usually averages about 28 per cent. sulphur, 3 per cent. nickel, .5 per cent. copper and 50 per cent. iron.

The plan proposed for utilizing the sulphur in this ore was to roast the pyrrhotite in a closed furnace, with the recovery of the resulting sulphur dioxide gas, which, after having been cleaned and cooled, was to be used for the following purposes:

1. In the manufacture of a "bisulphite liquor," of a character suitable for and to be used in the sulphite pulp industry.

2. In the manufacture of liquid sulphurous anhydride, intended as a reserve supply for the sulphite mill, in case of any stoppage or interruption at the roasting plant, or when the pulp mill would call for more or a stronger gas than that furnished by the roasters in operation; also intended as a separate commercial product to be disposed of for the purpose of refrigeration, ice-making, sugar refining, bleaching, disinfecting, etc.

3. In the manufacture of sulphuric acid—50°B, 66°B and 98 per cent. strong—for the great market open to such an industry, covering an extensive field from fertilizers to gold mining, and including manufacturers of fertilizers and soda water, oil refiners, dyers, furriers, cotton bleachers, brewers and galvanizers; and also for the rubber and hat trade, the woollen and wire mill; the nitro-glycerine and dynamite manufacturers.

THE ROASTING PLANT.

The question of greatest importance at this stage, conse-

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quently, was to find a method or roasting system by means of which a clean and sufficiently strong gas could be obtained at smallest cost. Roasting experiments were, therefore, carried out in a systematic manner in shaft and reverbatory furnaces; and the first conclusion reached was that the ore, in order to be successfully treated, must be crushed to a powder. It now happened that at this time the Herreschoff roaster for treating pyrite fines was brought to public attention, and receiving some encouragement from the designer as to the feasibility of this furnace accomplishing the desired aim (a dead roasting of the ore without any auxiliary heat), one of these roasters was purchased and erected at this place for trial purposes. In spite of every effort, and after a long series of tests, however, we found that this roaster, as constructed, would not answer our purpose—the roasting heat not being maintained by the combustion of the sulphur in the ore, and the gas produced being too diluted. The many excellent points embodied in this type of roaster being fully appreciated, attempts were at first made simply to improve on the weak points as applied to our special problem, but gradually a somewhat different type was evolved, containing some important changes, thanks to which the problem was eventually solved. These modifications consist of (1) a minimizing of the heat of radiation, (2) the application to best advantage of the roasting heat generated, (3) the exclusion as far as possible of an excess of air over and above that required for the oxidation of the sulphur in the ore, and (4) the application of an auxiliary source of heat, in case of need. And the special features embodied in the new roaster are the following:

1. The combination of four single furnaces in one battery, disposed equi-distant from a common centre.

2. A minimum distance between the floor and roof arches of the roasting chambers, made possible by the construction of the arm, and the manner in which it is secured to the centre shaft (it being secured in position by a horizontal motion and a quarter turn).

3. A round rabble arm, with a perfectly secure locking device, having both ends closed so as to prevent any inflow of air

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from the centre shaft to roasting chamber; the air of combustion being admitted through special pipes, provided with valves for a perfect control of the same.

4. Separate muffle chambers for the application of an auxiliary heat, and having no connection with the roasting chambers, the one under the bottom hearth being a combustion chamber, and those under the second and top hearths being heating chambers, through which the combustibles of the extraneous fuel pass from the combustion chamber, and thus utilized to advantage in heating the corresponding roasting floors.

5. A screw device for feeding the ore from the hopper to the roaster, the same being propelled by means of an endless chain from the main driving shaft.

This roaster is shown in Figs. 1 and 2.

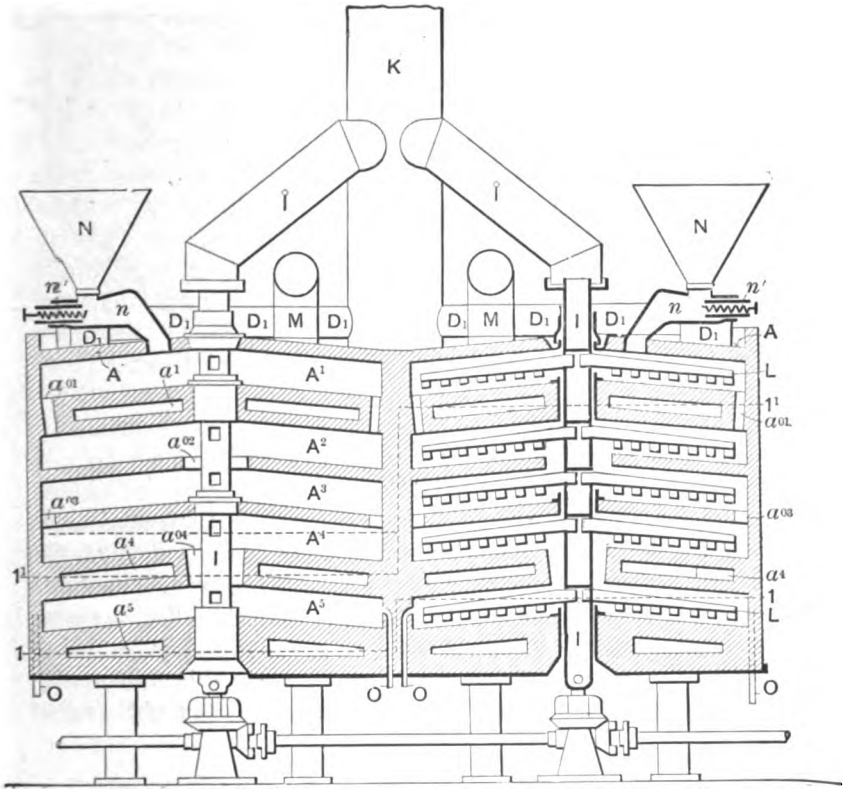

FIG. 1.—HORIZONTAL SECTION.

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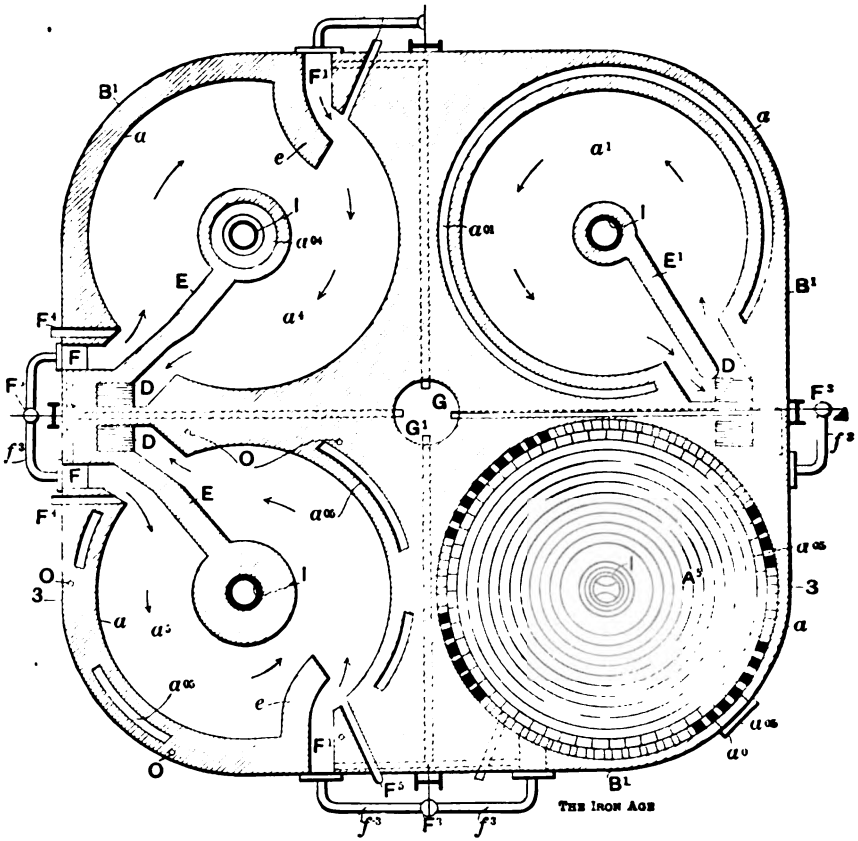

FIG. 2.—VERTICAL SECTION.

THE SJÖSTEDT ROASTING FURNACE.

Fig. 1 presents a battery of four furnaces in horizontal cross section, on the broken line 1 1 and 1′ 1′ on Fig. 2, showing the combustion chamber a^5, the lower and upper heating chambers a^4 and a^1, and the lower, or discharging, hearth A^6. Fig. 2 shows a sectional elevation of the battery on line 3 3, Fig. 1, being through the central columns of the furnaces, one side shown with th rabbles and one without. A^1 A^6 are five straight arched

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hearths; a^1, a^4 and a^5 the combustion and heating chambers. The flow of the fuel gas and combustibles is indicated by arrows. The gas (or oil) entering from main F^3 through f^3 and a suitable burner into the combustion chamber at F and F^1, strikes the hot baffle walls and is readily ignited, passes through the chamber and reaches the chimney flue D, which leads to the heating chamber a^4 over the lower roasting hearth. This chamber is also provided with a baffle wall, E, which extends to and surrounds the centre shaft I, separating the gas inlet from its outlet, and thus compelling the combustibles to make a full turn here before passing out and up through the upper section of chimney flue D to the heating chamber a^1, under the upper roasting hearth. Here it makes a similar circuit before finally passing out through the last section of D and flue D^1 to stack K, which is common to the whole battery of four roasters. F^4 and F^5 are peep holes for inspecting the heat in the combustion and heating chambers. G is an air receiver ("hot blast") in the centre of the battery, into which the air of combustion is introduced under pressure from a Root blower and heated from the brick walls with which it is surrounded, and thence carried through blast pipes G^1 to the burners at F and F^1. The ore, finely crushed, is introduced through an opening in the top of roof A of the upper roasting chamber to hearth A^1, from hopper N, by feed tube n, provided with an automatic screw charging device, n^1. Owing to the bottom heat furnished by heating chamber a^1, the ore is soon dried while being moved toward the circumference by the teeth of arms L, fastened to the revolving centre shaft I, and drops finally down to hearth A^2, through rim discharges a^{23}. The arms of this hearth, having their teeth placed in the reversed direction, now cause the ore to be moved toward the centre and discharge it through the centre openings a^{32} onto hearth A^3. By this time the sulphur has been largely removed, and the heat generated by the oxidation of the sulphur has diminished, but on reaching hearth A^4, heated within, a temperature sufficient for a further oxidation is maintained; so also on the last hearth, A^5, which is heated from within direct by the combustion chamber a^5. The rabbles finally cause the now roasted ore to be discharged through openings a^{56} and spout

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a^{40}, leading to the ore conveyer. O are pipes admitting and controlling the air supply for the roasting of the ore, and M a cast iron pipe leading from the top of arch A of each roaster, and through which the sulphurous gases pass out from the roaster to the main gas flue.

Four of these batteries of kilns—16 units—have been built, with a total capacity of treating forty tons of ore per day; also a crushing plant has been installed, consisting of one 24" x 15" jaw crusher, two 36" rolls and two revolving screens of No. 16 mesh, with a capacity of pulverizing about 80 tons of ore per shift of 10 hours; also two Dellwik-Fleischer No. 4 water gas generators, each having a capacity of producing 20,000 cubic feet of water gas per hour, or with a total capacity of about 800,000 cubic feet per day; also an electric installation of three 95 h.p. General Electric motors for supplying the required power.

THE ROASTING GAS.

At first water-gas was used as an auxiliary fuel, but by gradually improving the details of the roasters and gaining in experience we have finally succeeded in doing without it, and since then have roasted our pyrrhotite without any extraneous fuel (even at times when the sulphur in the ore averaged but 20-25 per cent.), producing a gas of sufficient strength (6-10 per cent. SO_2), for making bisulphite liquor and liquid SO_2; also a fairly well roasted ore, running as low as .20-.75 per cent. S when admitting a liberal amount of air and obtaining a weak gas, but generally from 1 to 3 per cent. S when producing a good gas.

A glance at the chemical reaction taking place in burning sulphur and in roasting iron sulphides will assist in forming an intelligent idea of the maximum strength of gas obtainable, as well as of the efficiency and significance of a 10 per cent. SO_2 gas from pyrrhotite:

When burning sulphur: $S + 2\,O = SO_2$,
i.e., all the O combines with the S to form SO_2
" " pyrite: $2\,FeS_2 + 11\,O = Fe_2O_3 + 4\,SO_2$;
i.e., 8 parts of O out of 11 unite with S " "
" " pyrrhotite: $Fe_6S_7 + 23\,O = 3\,Fe_2O_3 + 7\,SO_2$,
i.e., 14 parts of O out of 23 unite with S " "
" " " $2\,FeS + 7\,O = Fe_2O_3 + 2\,SO_2$,
i.e., 4 parts of O out 7 unite with S_6 " "

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The roasting being accomplished by means of air (instead of undiluted oxygen, containing 21 per cent. O, by volume), we readily find that the highest theoretical percentages of SO_2 obtainable are the following:—

When burning sulphur, S: 21 × 2 ÷ 2 = 21% SO_2 max.
" " pyrite, FeS_2: 21 × 8 ÷ 21 = 15.27 SO_2 "
" " pyrrhotite, Fe_6S_7: 21 × 14 ÷ 23 = 12.78 " "
" " " FeS: 21 × 4 ÷ 7 = 12.00 " "

The annexed tables from our daily records of two weeks' run in February last, during which time we used pyrrhotite only (and that of an inferior grade) will furnish exact data of results obtained under such circumstances:

COMPOSITION OF ORE USED (AV. SAMPLES TAKEN FROM EACH 40 TON LOT).

	a	b	c	d	e	Average
Insol	24.74	29.20	24.95	21.03	16.10	22.50
Sulphur	26.30	23.81	24.67	27.60	29.90	24.46

ROASTING RESULTS (AV. OF TESTS MADE EACH HOUR).

February	11-12	13-14	15-16	17-18	19-20	21-22	23-24
Strength of Gas % SO_2	8.60	8.30	7.90	7.90	7.40	7.60	7.70
Roasted Fines, % S	1.66	1.86	2.04	2.54	1.78	0.95	1.86

During these two weeks we treated 210 tons of pyrrhotite, containing 111,112 lbs. of sulphur, and recovered 191,917 lbs. SO2, thus obtaining an efficiency of 86 per cent. The average working cost, exclusive of heating and lighting the building, amounted to $1.86 per ton of ore treated, distributed as follows:—

Labor	$1.12	Crushing	$ .50
Power	.24	Roasting	.75
Repairs and Sund	.50	Sup., Rep. and Sund	.61
	$1.86		$1.86

If to this amount we add depreciation of plant (say 14 cents per ton), the cost of the raw ore (say $5.00 per ton) and the cost of briquetting the fines (say 75 cents per ton), and then subtract

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the value of the briquetted ferro-nickel ore (which we will assume to be equal to that of the unroasted ore, or $5.00 per ton), we obtain a total of $2.75 as the cost of 914 lbs. SO_2, equal to $6.00 per ton of SO_2 gas recovered, corresponding to $12.00 per *net* ton, or $13.44 per *gross* ton of sulphur.

It may be well to state here that at first no other raw material than pyrrhotite was used for the acid making, but some valuable deposits of pyrite having been discovered in close proximity to the company's iron mine, it was decided to use some of it at times when treating a low grade pyrrhotite, or when an extra supply of gas would be required. During the last half-year's run a few hundred tons of brimstone were also used, on account of shortage of both pyrrhotite and pyrite from the mines (caused by the company's financial condition at that time). Altogether 10,000 tons of pyrrhotite and 3,000 tons of pyrite have been roasted in these kilns, and 375 tons of brimstone used as raw material at our acid plant up to present time.

THE BISULPHITE LIQUORS.

Tilghman, in his patent involving the use of sulphur dioxide in reducing wood to pulp, states that his invention consists of a process of treating vegetable substances, containing fibres, with a solution of sulphur dioxide in water, either with or without the addition of sulphites, heating the same under pressure in a closed vessel to a temperature sufficient to cause it to dissolve the intercellular incrusting or cementing constituents, leaving the undissolved product in a fibrous state, suitable for the manufacture of pulp, etc. Owing to the smaller absorption of the sulphur dioxide by water than by a watery solution of metallic oxides, such as soda, lime or magnesia, the practice in pulp making is, therefore, to make use of such solutions in different ways—the system in use here being what is called the "tower system." This consists of a battery of high towers filled with a coarsely broken dolomitic limestone, through which runs a spray of cold water, while the roasting gas is forced up through the tower, meeting the weak lime solution thus formed, and is absorbed by the same, forming monosulphite of lime ($CaSO_3$) and magnesia; and upon the neu-

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tralization of the lime by the gas, the water absorbs free SO_2, forming an acid solution (H_2SO_3), which again dissolves some of the lime and magnesia salt, resulting in the formation of a solution of monosulphite of lime and magnesia in free sulphurous acid (H_2SO_3)—the so-called "bisulphite liquors." The desired strength of this solution is about 4% total SO_2 and 1% lime (5.5° B); and our experience here has taught us that for economically obtaining such a liquor a minimum of 5% SO_2 in the roasting gas is required.

The gradual progress and improvement made in our work in this department will best be seen from our first year's record hereby presented:

	Tons SO_2 Made	Tons SO_2 Recovered	Av. Strength of Gas, % SO_2	Efficiency of Recovery
January	228	163	5.9	71.4
February	208	107	4.7	51.4
March	221	165	5.3	74.9
April	249	173	4.7	69.3
May	197	125	4.1	63.2
June	250	163	5.0	65.6
July	265	125	4.6	60.3
August	265	117	5.1	44.3
September	285	205	6.6	71.8
October	241	205	6.7	85.3
November	252	221	8.1	87.0
December	260	255	12.6	97.0

This table also shows that from January to July, inclusive, the gas supply was constant but weak, and the absorption not sufficient (66%); also that during July and August, when the weather was warm, the efficiency was still more unsatisfactory, being only 52%; but that, after the installation of a larger cooler in August, a great improvement in the absorption was had, September showing 71.8% and October 85.3% efficiency; and finally that in December, when using part pyrite, a much stronger gas was obtained, and also (owing to the low average temperature (38° F.) of the absorbing and cooling water during this month), a nearly theoretical recovery of the gas was made—97% efficiency. Later

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on, after having made further improvements at the roasting and the absorption plants, we succeeded in producing an 8 per cent. SO_2 gas from pyrrhotite with less than 25 per cent. sulphur (as previously shown), and found subsequently no difficulty in making a gas of 8-10 per cent. SO_2 contents from a rich (30 per cent. S) pyrrhotite, and in obtaining a recovery efficiency of 70-80 per cent.

THE LIQUID SO_2 PLANT.

The principle underlying the liquifaction of diluted sulphur dioxide gas is quite simple, consisting merely in the absorption of the SO_2 by water (thereby separating it from the nitrogen and oxygen and other gases with which it is diluted), heating the acid solution obtained, so as to evaporate off the SO_2, dehydrating this acid gas, and compressing and cooling the dried gas. In practice, however, many difficulties present themselves for an economical solution of the problem, caused principally by the low degree of solubility of the gas in water of high temperature, and the poor absorption of a very dilute gas. The annexed table shows some of the values regarding SO_2—gaseous and liquid—at different temperatures:

Temperature		Vol. SO_2 Soluble in 1 Vol. H_2O	% SO_2 in a Saturated Solution	Sp. gr. of the Watery Solution	Pressure (in atms.) of the Liquid SO_2
°C	°F				
10	14	....	.....	.....	1.00
0	32	79.8	18.58	.....	1.53
5	41	67.5	16.19	1.061	1.80
10	50	56.6	13.93	1.059	1.26
15	59	47.3	11.92	1.054	2.70
20	68	39.4	10.13	1.042	3.24
30	86	23.4	.....	1.024	4.12
60	140	....	.....	.....	10

The above figures are correct only when dealing with 100 per cent. gas, as the solubility of the diluted gas is much smaller. For instance, a 10-12 per cent. volume SO_2 in the roasting gas will, at ordinary temperature, give a max. absorption of only 2 per

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cent. SO_2, instead of the 10-15 per cent. shown at temperatures between 10-20° C.

The requisites for an economical liquifaction, therefore, are as follows:

1. A strong gas, and gas flues free from leakage.
2. An effective cooling and cleaning system.
3. Cold water for absorption and cooling.
4. Large absorption towers.
5. An economical heating exchange (counter current) system.
6. Cheap fuel and economical heating and concentrating systems.
7. Ample compressor capacity.

All the above points have been carefully studied and applied in our liquifaction plant, the general arrangement of which is shown by the sketch 3. See Can. Mining Review, May number, page 95.

The roasting gas from furnaces A rises to gas main *a*, and is from there drawn off by means of a lead lined fan, D through a cooler, B, and spray tower, C, and then forced through absorption tower, E, where it meets a shower of water, by which it is absorbed, leaving the nitrogen, oxygen, and other gases to escape at *c*. The acid solution leaves the tower at *e*, and runs by gravity through preheater, F, overflowing through pipe, *f*, into heating pan, G, where it obtains its final temperature for driving off the SO_2 contents, and from which the hot spent liquor runs through pipe *f* back to the preheater. In this apparatus, built on the counter-current and heat-exchange principle, the outflowing spent liquors give up their heat to the inflowing cool acid solution. When brought near boiling point, the solution gives up its SO_2, which then, together with some steam, rises up through the gas out-take, *g*, to condenser, H, where most of the vapor is precipitated, and then to the dehydrating tower, I, where its last trace of moisture is absorbed by the strong sulphuric acid entering the tower through pipe *k*. This acid, on being diluted by the absorbed water, runs by gravity through pipe *i* to acid pan, J, where it is evaporated and concentrated to full strength, and run

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off through *j* into acid eggs, K, from which it is again forced through *k* back to the dehydrating tower. The now pure and dry SO_2 gas passes through suction pipe, *i*, to compressor, L, where it is subjected to the required pressure; is then cooled and liquified during its passage through discharge pipe, I, and cooler, M. to storage tanks, N. From these tanks the SO_2 can either be drawn off in liquid form at *n'*, or in gaseous state at *n''*, as desired.

With roasting gas of 7-9 per cent. strength, and with the cooling and absorption water with a temperature of 40-45°F. we obtain an absorption of 70-80 per cent. efficiency, and maintain the strength of the acid solution at 1.2-1.5 per cent. SO_2, the temperature of the gas entering the tower being 70°-80°, and the solution leaving the tower at about 45° F., entering the preheater at about 165°, is here further heated by exhaust steam to about 188°, and thus the balance of only 24° F. needs to be furnished by direct fuel.

The capacity of the plant is from 8 to 12 tons of liquid acid per day, and the cost of liquifaction includes the following items:

Fuel	$1.00	per ton
Power (Electric)	1.00	"
Water, Light and Incidentals	1.00	"
Labor and superintendence	1.75	"
Depreciation and repairs	1.25	"
	$6.00	
2 tons SO_2 gas @, say, $8.00	16.00	
Total cost of one ton of liquid SO_2	$22.00	

THE SULPHURIC ACID PLANT.

Sulphur dioxide gas, in presence of free oxygen and steam will form sulphuric acid ($SO_2 + O + H_2O = H_2SO_4$.). For this industry a weak gas is not only permissible but even necessary, a surplus of oxygen being required. In fact the sulphuric acid makers do not want any stronger gas than 8 per cent. SO_2, while one of the most prominent consulting engineers has advised us that even "with 5-6 per cent. SO_2 gas, sulphuric acid can be produced, at a very low cost, that will compete with any manufactured from pyrite."

In the manufacture of sulphuric acid two systems are now in use, namely, the Chamber system and the Contact system:

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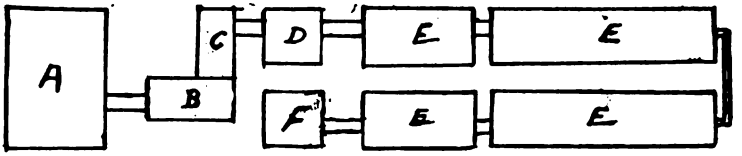
but the one especially recommended to us is the old Chamber system. As planned, this plant will have a capacity of 30 tons 50°B.=21 tons 66° B. acid, and will be arranged in the following general manner:



The gas from roasting furnaces, A, enters first into nitre oven, B, where it is mixed with nitrous vapors, then to dust chamber, C, hot-tower, D, and lead chambers, E, where, under influence of steam and at the expense of oxygen of the nitrous acid, it is converted into nitric oxide and further oxidized (by the air present in the chamber) into nitrous acid, which again is decomposed by SO_2, etc.—the process being continuous. From here the sulphuric acid formed passes through cold-tower, F, filled with coke, where it is freed from its mixture of nitric and hyponitric acids:

$$(SO_2 + N_2O_3 + H_2O = H_2SO_4 + 2\,NO)$$

The daily cost of manufacturing a 50° B. acid from pyrrhotite or pyrite in the above named plant would include the following items:

	Pyrrhotite 30% S	Pyrite 45% S
Pyrrhotite, 25 tons @ $5.00	$125.00	.....
Pyrite, 15½ tons @ $5.00	.....	$ 77.50
Nitrate of Soda, 420 lbs @ $2.25	10.50	10.50
Steam	10 00	10 00
Labor	8.00	8.00
Repair, 25c. per ton S	1.75	1.75
Depreciation, 10% on $50,000.00	15.75	15.75
Total cost	$171.00	$124.00
Deduct values of the roasted fines	100.00	15.50
Net cost per day	$ 71.00	$108 50
Net cost per ton 50°B Acid	$ 2.37	$ 3.62

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CONCLUSION.

From the data above given we find that the pyrrhotite not only can be roasted without the aid of special fuel, but also made to yield a sufficiently strong SO_2 gas for the sulphite pulp industry, for liquifaction and for the manufacture of sulphuric acid, thereby giving to this much neglected mineral a value and an opportunity which it never had before.

But before concluding, I wish to explain my position in this respect, and to state that my contention is not that pyrrhotite necessarily is the most economical raw material for the acid industries under all circumstances, but that, when a pyrrhotite contains some other valuable elements (such as nickel, cobalt and copper) and where the prevailing practice is to roast the same before smelting, and when a deposit of magnetic pyrite can be obtained at the cost of mining and can be used for local consumption, the monosulphide of iron stands a fair chance of being a cheaper source of sulphur for the above mentioned manufactures than brimstone or pyrite bought (at market price) at a distance. And, consequently, many magnetic pyrite deposits, heretofore considered worthless, may become of economical value.

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Journal of the Canadian Mining Institute, Vol. VII.

THE EARLY HISTORY OF MINING IN THE SUDBURY DISTRICT.

By J. W. Evans, Deseronto, Ont.

Toronto Meeting, March, 1904.

Although nickel was reported as having been found in the Sudbury district as early as 1853 by the Geological Survey, it was not until the advent of the Canadian Pacific Railway in the district that any attention was paid to its mineral resources. Up to the year 1883 this section of the country was untrodden by the foot of white man, with the exception of the officers of the Hudson Bay Company and the Geological Survey, whose travels were confined more to the immediate vicinity of the lakes and rivers, and little was known of the minerals of the district.

The surface of the country is more or less broken by rocky ridges well wooded with hemlock, pine and birch, with spruce, tamaracks and alder swamps in the valleys between the ridges. Extensive forest fires raged throughout this section in the thirties and forties, destroying the heavy timbers and leaving vast tracts of dead pine standing like grim sentinels to mark what had at one time been immense pine forests, with little or no undergrowth to mar the beauty of fine straight pines.

Following these fires, second growth timber sprang up and rank vegetation in the form of ferns and bracken, with alder and willow and blueberry bushes covering the surface, until now comparatively free from undergrowth. Smaller fires raged from time to time, destroying this second growth and exposing the rocks to the action of the weather, which soon attacked the ore where exposed and converted it into gossan.

The first indication of the presence of mineral was shown during the construction of the Canadian Pacific Railway in a cutting on the main line about 4 miles northwest of Sudbury, afterwards known as the Murray mine, and the second was in a cutting on the Soo branch of the C.P.R. about 25 miles southwest

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from Sudbury. This property was first known as the Crane mine and afterwards as the "Worthington."

Surface indications showed the mineral deposit to extend for several hundred feet in a northeast direction, across a small stream and over a ridge on the other side. This property was bonded by some New York people, who sent an expert from New York to direct prospecting operations, during the summer of 1885, and a shaft was sunk to the depth of about 60 feet on the top of a ridge. A small quantity of copper ore was obtained, but not in sufficient quantities to promise a paying mine, and finally the property was abandoned.

Prospecting in the district began in 1884 among the pioneers being Thomas Frood, R. McConnell and James Stobie. Mr. Frood discovered some promising looking properties in the spring of 1885, and associated himself with Messrs. McAllister and Medcalf, of Pembroke. They began development work on a find on lot 1, con. 3, township of Snider, known as the McAllister mine. A shaft was sunk about ten feet deep, and the prospects looked promising for a paying copper mine. The surface indications at this point were quite extensive, extending continuously for several hundred feet in a southwesterly direction up the slope of a high ridge and were in places 100 feet in width. Subsequently in 1886 this property was visited by Lady McDonald, in company with a party of Montreal capitalists, among whom were W. C. Vanhorne, Sir George Stephens and Sir Charles Tupper. In honor of the visit the name of the mine was changed to the "Lady McDonald mine." In addition to the above mentioned discoveries, prospecting had been done at other points, the most notable being by Thomas Frood and associates, on lot 6, con. 6, McKim, and by R. McConnell on lot 1, con. 4, township of Snider.

Up to this time (the end of the season, 1885) nothing had been done but prospecting, and this in the simplest manner, and copper was the only metal of commercial value known to exist in the district. During the year 1885 Mr. S. J. Ritchie, of Akron, Ohio, visited the district and took over several properties, and during the winter of 1885 and 1886 the Canadian Copper Company was formed to operate these properties, among them being

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the McAllister, now Lady McDonald, mine. The McConnell mine, lot 12, con. 2, McKim, later the Copper Cliff mine, lot 6, con. 6, McKim, and lot 1, con. 1, Creighton.

Late in the season of 1885 the S.½, lot 1, con. 1, Snider, was discovered by F. J. Eyre, and was purchased by the Canadian Copper Company in 1886. This was afterwards known as the Evans mine. The Stobie mine, on lot 5, con. 1, Blezard township, was discovered by James Stobie, and some prospecting and development done on it.

The Canadian Copper Company bought this mine also in the summer of 1886, and a railway was built from Sudbury to the mine, a distance of 4 miles.

When the spring of 1886 opened the Canadian Copper Co. began prospecting and developing several properties on a large scale. Work was begun on lot 12, con. 2, township of McKim, afterwards known as the Copper Cliff mine. An open cut was made in the south side of the hill and ore was exposed upon working through the sand and gossan which covered the surface. The ore consisted of pyrrhotite and chalcopyrite. As the pyrrhotite was considered valueless the presence of nickel not being suspected, it was thrown out on the waste dump.

A railway was constructed from the Soo branch of the Canadian Pacific Railway to the mine, in the month of September, a distance of about one mile.

Several hundred tons of picked copper ore were shipped during October to New York, upon the treatment of which the presence of nickel in the ore was discovered.

Prospecting was continued at the McAllister mine and at the McConnell mine, and it was at this time that the Eyre mine, afterwards the Evans mine, was purchased by the Canadian Copper Company, and a vertical shaft was sunk on the property.

Mr. R. McConnell discovered mineral on S. ½ lots 2, 3, 4, 6, 8 and 9, con. 5, and N. ½ 8, 11 and 12, con. 4, Denison township, at this time and sunk several test pits and stripped the surface, exposing a quantity of ore. This property is now "Victoria Mines."

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In the month of October of this year the S. ½ lot 7, con. 6, McKim, was purchased by the Canadian Copper Company from Thomas Frood, P. C. Campbell and Robert Tough for the sum of $30,000. This was the highest price paid up to this time for any mining property in the district.

Owing to the want of a practical method of treating the nickel ores the year 1887 did not show a marked increase in mining activity, and few further discoveries were made. In the winter of 1887-8 the Canadian Copper Company secured the services of Dr. E. D. Peters, who planned and erected the first smelting plant in the district. This consisted of an extensive roasting yard with elevated and level track, one 100 ton Hereshoff smelting furnace with blowing engine pumps, etc., which furnace was blown in in December, 1888, and proved a success from the first; the product being a nickel and copper matte containing from 15 to 20 per cent. nickel and 20 to 25 per cent. copper. A second furnace was added early in the summer of 1889.

During the year 1888 a spur was built from the Canadian Pacific Railway Soo branch to the Evans mine, and ore was brought from Copper Cliff, Evans and Stobie mines to the roast yards, which were located about half a mile from Copper Cliff mine and near the smelting plant. The ore from the three mines differed somewhat in character. That of Copper Cliff mine carrying a higher percentage of copper, and was an intimately mixed ore of pyrrhotite and chalcopyrite; the nickel and copper percentage being about equal, although picked samples of pyrrhotite often assayed as high as 12 per cent. nickel, which was probably due to the presence of the mineral pentlandite disseminated through the pyrrhotite.

The ore from the Stobie mine consisted of large masses of pyrrhotite free from rock and carrying a much smaller percentage of chalcopyrite than Copper Cliff mine ore, and assaying little over 2 per cent. each of copper and nickel. The ore from the Evans mine carried about 3 or 4 per cent. each copper and nickel. It was found that the Stobie ore, although lower in nickel and copper, carried more iron, and aided the smelting operations, the excess of iron assisting the fluxing quality of the other ores.

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It was not until this year, 1889, that other mining and smelting companies entered the field. The first one being the Dominion Mineral Company, who opened and developed the Blezard mine, discovered late in the summer of 1889. This mine is distant about a mile and a quarter north from the Stobie mine. It is not being worked at the present date, having closed down in 1893, the ore having been worked out. This company secured the Crane mine or Worthington about the same time and shipped the ore to the furnace at the Blezard mine for treatment. Operations were stopped in 1893 or 1894. Some very rich ore came from this mine, some carrying high silver values. In 1889 the Murray mine was secured by the H. H. Vivian Co., of Swansea, and a mining and smelting plant was erected. This mine was worked about five years when it was closed down, and no work, except a little diamond drilling, has been done since.

Gold was discovered on lot 6, con. 4, Denison township, in 1887, and a company was formed called the Vermilion Mining Company to work the property and other lots in the vicinity. The vein did not carry gold to any great depth, however, and operations were soon suspended. Nickel and copper ore was discovered a short distance from the gold vein on the same lot, which was very rich in nickel, an average of several carloads assaying 17 per cent. nickel. Sperrylite or arsenide of platinum is associated with this ore and was found in crevices in the shaft and in the gossan from the decomposing ore on the dump. In the year 1890 this mining company passed into the hands of the Canadian Copper Company, and all mining operations on this property have been suspended. Many deposits of nickel ore of more or less extent have been discovered throughout the district since 1890, but as I only intended touching on the early history of mining in the district I will stop at this year (1890) and leave the later history of mining for those more familiar with the present conditions of the Sudbury region than myself.

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Journal of the Canadian Mining Institute, Vol. VII.

NOTES ON THE SPECIAL FEATURES OF COAL MINING IN THE CROW'S NEST, B.C.

By Jas. McEvoy, M.E., Fernie, B.C.

Toronto Meeting, March, 1904.

To one familiar with the methods of bituminous coal mining in an Eastern field the successful management of a colliery in the West is not always an easy task. This is especially the case in the Rocky Mountain coal basins, where he finds himself face to face with conditions requiring considerable modifications of his Eastern methods, if not an entirely different system of their own. A knowledge of the causes giving rise to the new conditions, helps him to meet them with intelligence, and to foresee and provide against any new difficulties which may arise.

The geological history of the Eastern and Western coals when compared show similarity, if the two factors, "time" and "force" be kept out of consideration. The Eastern coals are practically all of carboniferous age. A possible exception to this is in Virginia and Kentucky, where some of the coals may reach as high as the Triassic. Since their deposition they have gradually at an infinitesimally slow rate of progress been developed through the various stages from the original peat bed up through the different varieties of lignite to their present bituminous form. It is beyond the knowledge of man to ascertain the length of time which elapsed during this development. There was, generally speaking, little disturbance of the measures and the beds are found to-day in attitudes more or less closely approximating their original horizontal position.

The Western coals are chiefly of cretaceous formation and consequently are four geological ages younger than the Eastern ones. They have gone through all the same stages as the Eastern coals, but their development has been accomplished in one-half the time.

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After the deposit of the peat beds all those that are preserved to-day in the form of coal, were covered by succeeding layers of clay, sand or gravels, which are now seen in the form of shale sandstone and conglomerates overlying the coal. The accumulation of a great thickness of these superincumbent strata brought an intense pressure to bear upon the peat beds at the bottom and they were compressed to about one-twelfth of their original thickness. The continuation of this pressure, and the consequent heat developed, gradually drove off the excess of moisture and more or less of the volatile constituents. Any movement of the strata resulting from the shrinkage of the earth's crust naturally increased the pressure and heat and hastened the alteration.

It has been due to greater activity in these earth movements that the Western coals have been altered to their present form in so much shorter time.

The Rocky Mountain region in most parts was the scene of tremendous movements, and great pressure is evidenced by the crushing, thrusting, folding, faulting and uplifting of the measures.

The comparatively speaking newer rocks, such as the cretaceous, sometimes suffered equally with the older ones of the region, and some large areas which under quieter conditions would have produced valuable coal fields were crushed and broken and eventually swept away by the denudation of succeeding ages. In other parts the movements were less violent, and where the pressure and heat were sufficient to produce the required degree of alteration of the coal without crushing the main portions of the basins, some of the highest grade bituminous coals are found in good workable form.

The greater the degree of alteration the more moisture and volatile matter were driven off and the higher the percentage of fixed carbon remaining. Near the axis of the Rocky Mountains the conditions were most favorable for the development of good coal and the percentage of fixed carbon is generally between 65 per cent. and 78 per cent. Going eastward from the axis of the Rockies the pressure gradually diminished and the fixed carbon is found to decrease while there is a corresponding increase in

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moisture and volatile matter in the coals. Continuing eastward the coals soon become lignitic in character and when the great plains are reached they are represented only by lignites proper.

The Crow's Nest field, situated just west of the main divide, suffered to some extent like the rest of the region. Its edges were turned up and a wide strip, now the Elk River valley, was broken and carried away by erosion, but the main body of the field was lifted bodily up without any serious distortion. Generally speaking the measures of the Crow's Nest field as they stand to-day are bent upward all around the western edge of the field. The bending is almost universally gradual and regular, changing the attitude of the coal seams from horizontal to an extreme pitch of 40° in a distance of about three miles.

At three places on the western edge of the field tributaries of the Elk River, which run partly or entirely across the field, have cut out deep valleys, thus making the coal seams accessible by level entries at places where the seams are more or less closely approaching the horizontal position. The highest seams in the main group of coal measures are exposed at points farthest up the valleys, and consequently they are lying flatter than the lower ones where the latter are exposed by the same streams lower down and nearer to the edge of the basin.

At Morrissey, Fernie and Michel, situated respectively on the three transverse streams before mentioned, the Crow's Nest Pass Coal Company is carrying on active mining operations. At Coal Creek, the oldest of these collieries, the upper seams are lying in attitudes varying from horizontal to a dip of 15°. The lower seams on the same creek dip as high as 20°. At Morrissey the dips vary from 8° to 24° and at Michel they run from 15° to 35°.

It is evident that a system of mining and handling the coal in a flat seam will not apply to all these cases. Where the dips are moderate the equipment is simple, like that for a flat seam, horses drawing the cars from the working places to the main haulage roads. With the steeper dips incline planes are used, on which gravity does the work of lowering the cars to the main roads. Horses are then only employed on the secondary levels.

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Rooms are driven up the pitch from the levels, and in each room there is a simple self-acting incline or McGinty which is operated by the miners themselves. Where the dip approaches 35° chutes are used in the rooms, and the coal is drawn from these into cars on the levels.

To obtain the greatest economy in handling the coal the main haulage roads must be carefully laid out to take every advantage of the ground. Incline planes must be so located as to concentrate the work of lowering the cars. For this reason each incline is laid out so that it takes the cars from a set of rooms 15 to 20 in number on each side at every successive level. Without a proper system and equipment the cost of handling the coal in a pitching seam is greater than for a flat one, but these once being installed the arguments are by no means all in favor of the flat seam.

The physical and chemical properties of the coal depend to some extent upon the amount of cover now overlying the seams, but are affected to a greater extent by the pressure which has been exerted by the bending of the measures and by the manner in which the strata have yielded to the bending movement.

Where the seams are lying flat or nearly so assays like the following one, made from a sampled specimen of coal from the face of No. 2 mine, Coal Creek, are usual:

Moisture	0.41
Volatile matter	24.78
Fixed carbon	68.36
Ash	6.45
	100.

The bodily tilting-up of the seams when unaccompanied by bending does not materially affect the constituents, as may be seen from the following assay of an average specimen from the face of the main level of No. 8 mine, at Michel:

Moisture	0.99
Volatile matter	23.64
Fixed Carbon	67.99
Ash	7.38
	100.

The seam on which No. 8 mine is operated is tilted up to an angle of 30° to 35° without bending.

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Where the measures are bent even slightly, if it continues for some distance on either side, there is a noticeable increase in fixed carbon and a corresponding decrease of volatile matter. The resulting coal is rather better in quality, having greater heating power. An example of this may be taken from No. 4 mine, at Michel, across the valley from No. 8, where the measures are dipping about 15° and where the attitude of the rocks outside show that there was a slight bending movement; the assay from No. 4 mine is as follows:

Moisture	0.63
Volatile matter	21.44
Fixed carbon	73.85
Ash	3.23
Sulphur	.85
	100.

A similar example may be taken from No. 1 mine, at Morrissey, where the bending conditions are more pronounced:

Moisture	0.65
Volatile matter	13.48
Fixed carbon	78.88
Ash	6.40
Sulphur	0.59
	100.

These assays were all made by Mr. R. W. Coulthard.

As regards physical properties of the coal it appears that when the roof and floor have held the coal under intense pressure during the bending movement the coal remains firm. In some instances, however, this has not been the case, and the roof and floor have apparently yielded readily to the induced lateral pressure, allowing the seam to "thicken out." The result is then that a certain amount of shearing has taken place and the coal mines free producing a higher percentage of slack. This is an advantage rather than otherwise, when so much slack coal is needed for making coke, as it saves the cost of crushing lump coal.

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Journal of the Canadian Mining Institute, Vol. VII.

EXHAUST STEAM BOILER FEED WATER HEATERS.

Hot Water Pumps and Pumping.

By W. D. L. Hardie, C.E., M.E., Lethbridge, N.W.T.

Toronto Meeting, March, 1904.

We do not know of any subjects more worthy the attention of mining men than the two we have adopted as titles for this paper. It is the purpose of the writer to re-hash in this paper much that may be old to many of our members, but of great importance to the younger ones, who have not traveled over the whole subjects of discussion here, and also to give some information that has come to the writer in his practice.

The primary object of a heater is to raise the temperature of the water and thereby increase the efficiency of the boiler plant either by reducing the coal consumption or increasing the capacity of the boiler plant; but there are several other objects to be gained of nearly as much importance as the primary one. If these were named in the order of their importance they might take the following classification:

1. Increase of temperature of feed water.
2. Reduction of danger that is due to effect of cold water on boiler plates when under high pressure.
3. Precipitation of a large percentage of scale forming matter before it enters the boilers.
4. Reduction of scale in boiler, which is another great source of increased usefulness of the boiler plant.

It is fairly well known that sulphate of lime, carbonate of lime and magnesia in connection with sand and other earthy matter are the large scale formers. Sulphate of lime will not precipitate at less than 300°F., and cannot be eliminated by an exhaust steam heater without the aid of chemicals, but the carbonate of lime and magnesia, etc., can be precipitated at from 160°F. to 204°F., which is quite within the range of exhaust steam

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heaters. These in many water supplies form the large percentage of impurities. In most cases under my own observation, if bad mine water be excluded, from 75 per cent. to 85 per cent. of the impurities in water objectionable to boiler feed can be precipitated within the temperature of exhaust steam.

There are, strictly speaking, two distinct classes of feed water heaters—the open and the closed—but these two classes have innumerable divisions. The closed heater consists of a shell with coils of pipes within and has two principal divisions:

1st. The water is pumped through the coils and the steam is exhausted into the shell and surrounds the coils, heating the water as it passes through the coils into the boilers.

2nd. The steam is exhausted through the coils and the water gravitates or is pumped into the shell and from there re-pumped into the boilers.

The open heater consists of a shell, into which the steam is exhausted. This class of heater has a large number of divisions, the principal ones being:

1st. The heater in which cold water is allowed to gravitate into the shell, and from there pumped into the boilers. The exhaust enters at one end and escapes at the other.

2nd. The heater in which the water gravitates into the shell and from it pumped into the boilers. Exhaust steam is attracted by vacuum into the shell. The steam has no thoroughfare through this heater.

3rd. The heater in which the water gravitates or is pumped through a coil into the shell and the exhaust enters one end of the shell and exits at the other. The hot water is pumped from the shell into the boilers.

In the case of the closed heater, if used simply for heating pure water by radiation, good results may be expected, but in the case of impure water they cannot remove any of the impurities or prevent formation of scale in the boilers. If sufficient temperature is obtained to set free and precipitate the earthy salts in the feed water, they will settle on the surface of the tubes and shell, forming scale, and reduce the efficiency of the heater. In the best makes of this class of heater all possible arrangements are made

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for cleaning, but it can scarcely be said that they are ever entirely satisfactory. Our own experience is that this class of heater requires much care, considerable expense in overhauling and repairing. We will, therefore, dismiss the closed heater and deal more particularly with the open heater.

Prof. Chandler, the chemistry expert, says that "boiling water expels the free carbonic acid and causes the separation of the carbonate of lime and magnesia." If the carbonic acid gas, hydro-chloric acid gas and other gases and the majority of the scale forming matter can be extracted from the water before it enters the boilers we have gained a great end. It must be remembered that the evil effects of scale are due to the fact that scale is relatively a non-conductor of heat. It has been demonstrated that a scale 1-16 of an inch thick requires the extra expenditure of 15 per cent. more fuel, and the proportion increases with the thickness of the scale; when scale is ¼-inch thick 60 per cent. more fuel is required, and at ½-inch thickness of scale 150 per cent. more fuel is required. These figures are appalling, but true. However, the worst features are as follows: To produce steam at 90 lbs. pressure per square inch the temperature must be 320°F., which may be secured by heating the external surface of a ¼-inch plate to 325°F., but if ½ an inch of scale is on the internal surface ot the plate 700°F. will be required. A mighty good reason to keep the scale producing matter as low as possible.

But there is still another very important point which I wish I could impress very strongly on the younger members, viz.: At any temperature above 600°F. iron soon becomes granular and brittle from carbonization, a condition of high-class cast iron. This produces weakness of the plates and causes repairs, and predisposes to sudden explosions.

We think it a fair proposition, that, except where more than ordinary care is taken, about ⅛-inch thickness of incrustation will take place on boiler the first year, and increase at a greater ratio each succeeding year. This is more especially true of boilers that have parts not easily accessible.

In addition to extracting the earthy salts from the feed water the open heater has the other advantage of condensing the exhaust

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steam into pure water for boiler feed, thus reducing the amount of water required by as much as 5 per cent. to 15 per cent. For example take 6 lbs. of water at 50°F., which will condense 1 lb. of water out of the exhaust steam, which is at a temperature of about 212°F., and at the same time raise the temperature of the whole to about 212°F., so that for 6 lbs. water at 50°F. delivered into the heater we get 7 lbs. delivered into the boiler at about 212°F.

With the closed heater, in getting 7 lbs. of water into the boilers at 212°F., we would have sent 1⅙ lbs. into the atmosphere as exhaust steam. The condensed steam ordinarily amounts to about ⅙ of all the cold water used. It would seem that steam space is not of particular advantage so long as the cold water is properly broken up so that the steam may be brought into contact with it, and there is sufficient space for free passage of the steam through the heater without lifting water and without creating any back pressure. However, some manufacturers of exhaust steam heaters make the rule of allowing one-half square foot of heating and lime-catching surface and 34¼ lbs. of water for each horse-power. In such heaters no filtering arrangement is made, dependence being put altogether in the iron trays used for breaking up the water and receiving the deposits. By the following excerpt from an old writer, we see that the open heater with the trays in an old boiler shell is a very old idea:

"At East Howle Colliery, Durham, England, the exhaust steam is turned into an old boiler. Cold water enters at the top and is allowed to fall on to a series of horizontal trays placed one below another in step form. The feed water is heated to 200°F. and is then forced by a donkey pump into the boiler."

It will be objected by the closed heater advocates that we have not said anything about the very objectionable feature of the oil going into the feed water of the open heater with the exhaust. Later on we will give a description of several open heaters which will show how this objectionable feature is eliminated, but just now we will take the case of an open heater which consists of simply an old boiler shell set either longitudinally or upright, with an inlet and outlet for the exhaust. In such an arrangement

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the water is always carried at some distance above the bottom and the outlet to the pump is high enough at some part in tne suction pipe to prevent the water falling below this line if the float did not sufficiently control the cold water supply. This causes the oil to float on the surface of the water and is blown off at regular intervals. This method is practiced at some collieries with marked success. The heavy impurities are precipitated to the bottom of the heater, which is cleaned out regularly.

With open heaters the maximum attainable temperature in the water, if the amount of exhaust steam is sufficient in amount, should not be more than from 1°F. to 4°F. less than the temperature of the exhaust steam when entering heater. The saving in fuel, or what is the same thing, increase in capacity of the boilers, should be 1 per cent. for every 10°F. the temperature of the water is raised. When the boilers are forced or inferior coal is used, the percentage of saving, or increased capacity, is greater.

In the writer's opinion, where the water is particularly muddy or contains lime, magnesia, etc., a filter should form part of the heater, otherwise much of the scale forming matter, after being precipitated, is pumped into the boilers and there formed into scale, and one of the principal benefits of the open heater lost.

When the feed water contains incrustating materials not disengaged and precipitated at the temperature of the exhaust steam or by the filteration of the feed water, an apparatus should be attached to the heater by which the feed water can be treated with the proper chemicals to separate and remove the scale forming materials before they are pumped into the boiler. Water impregnated with large quantities of sulphates of lime and magnesia and little carbonate or silicate of lime will cause a soft formation inside the heater, mostly on the pans, but if pumped into the boiler will give a very hard scale.

In the case of heaters, part of which consists of a filtering arrangement, there must be sufficient water-carrying capacity to permit a very slow travel of the water through the filtering material.

Following are given cuts and descriptions of a few of the best open exhaust heaters on the market to-day:

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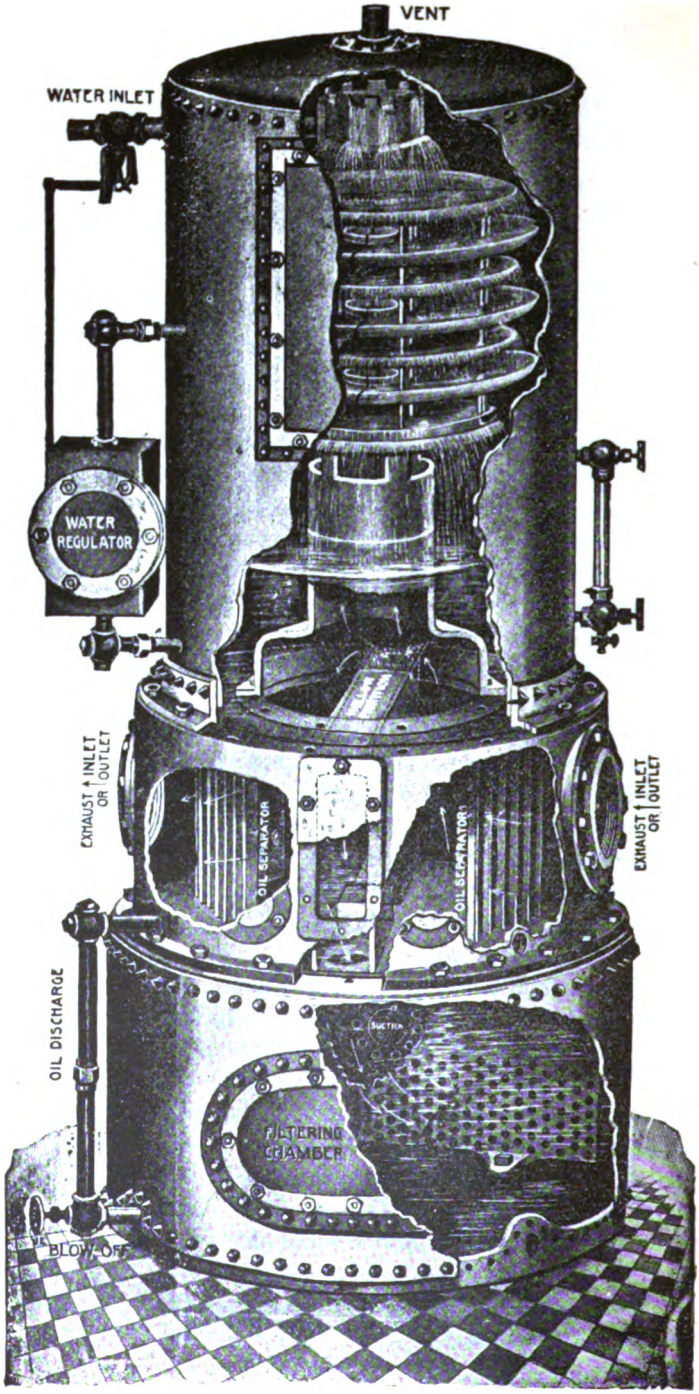

HEATER NO. C.

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DESCRIPTION.

Exhaust steam is admitted from either side and exhausts from the opposite side. The steam entering from the right-hand side, as shown, strikes the "V" shaped oil separating plates which divide the volume of steam; the ribs on these plates catching the oil and moisture in the steam, the separation is completed by the expansion of the steam in the chamber. The purified steam then enters into the enlarged portion of the exhaust tube (same being cut away to show its course) where it passes into the opposite expansion and oil separating chamber where the steam is further purified, and discharges to the atmosphere or heating system. At the top of the heater is a vent pipe for carrying off the air and gases relieved from the water in heating. The vent pipe must be connected with the exhaust outlet or atmosphere. The air being thus removed from the upper or heating chamber. The cold water supply from the city mains or tank now entering in a spray condenses the steam, forming a vacuum which draws the required amount of steam to heat the water up the large tube in the centre. But only that amount of steam necessary to heat the water comes in contact with it, the balance passes on in its dry purified state to the heating system or atmosphere.

The water supply is connected to the water inlet valve, which is opened and closed by the water regulator, maintaining at all times a uniform water level in the heater. The water entering the spray box at the top of the heater overflows same in a spray to the pan below; overflow from this pan sprays into the next. The water passes from this second pan through its centre to the next pan below and so on down. The last pan is bolted to the top of the exhaust tube. The water sprays from this last pan to the water below. All pans, with the exception of the bottom one, are loose, made in halves and are readily removed through the manhole. The object of these pans is to catch the lime deposit. The water after having been heated in direct contact with the steam enters the hollow partition at the back of the exhaust tube. (The dotted arrows show the water entering the opening in the hollow partition.) The water discharges from the hollow partition near the

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front into the filtering chamber below, where the remaining impurities in suspension are removed by filteration. It is obvious that the water in the hollow partition is kept at the boiling point by having steam on both sides of it at all times. The filtering chamber is filled with coke or excelsior and at the back of this chamber is a perforated plate preventing the filtering material from passing through to the pump. A strainer plate is also placed at the blow-off connections. The blow-off and oil discharge pipe must be placed on the side opposite the exhaust inlet; openings are tapped for that purpose. The two oil separating chambers are connected by a small opening through the hollow partition at the bottom, through which the oil and condensed water drain from one chamber to the other. All chambers are provided with large manholes and handholes for cleaning. The manhole in the upper chamber is hinged, making it an easy matter to open the heater for examination and the removal of the lime catching pans. Exhaust flanges, suction and return flanges are also removable; and a heater will be furnished with any sized flanges desired up to the capacity of the heater. The water inlet valve is balanced, having a double valve, and is made entirely of brass. The water regulator contains a seamless copper float; and all connections, stuffing-box, etc., are of brass to prevent corrosion.

CONSTRUCTION.

It is constructed in part of cast iron and steel plate, and in such a manner that it can be taken entirely apart with a monkey wrench. Being made on the interchangeable plan, any parts may be duplicated in the event of accident or partial destruction from fire. The top section is of steel plate, the centre section is of cast iron and in a single piece, including the shell, top and bottom heads, oil separating plates and the two walls forming the hollow partition. The bottom section or filtering chamber is made with a heavy cast iron bottom and cast ring at the top to which the steel shell is riveted. Heaters of 400 horsepower and under, this chamber is made of cast iron and in one piece. These three sections are securely bolted together with special gaskets and constitute the main structure of the heater.

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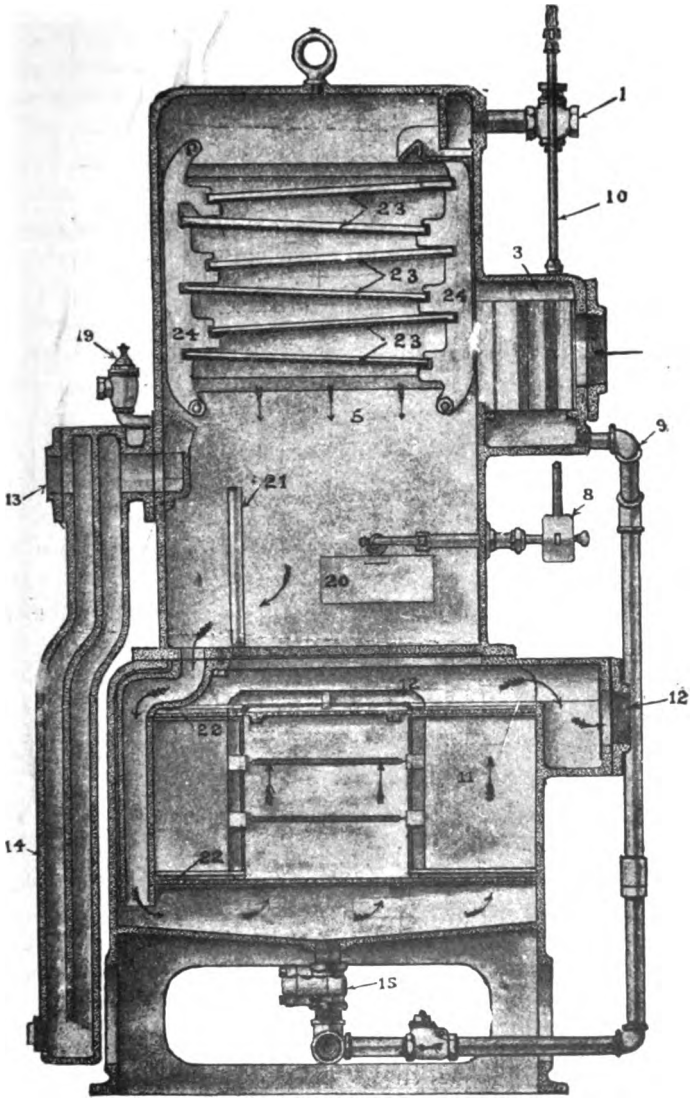

HEATER NO. 2.

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DESCRIPTION.

1. Water controlling valve.
3. Oil separator.
4. Exhaust steam inlet.
5. Heating chamber.
8. Counter balance weight for sink pan.
9. Oil drip connection with check valve.
10. Connecting rod between sink pan gear and water controlling valve.
11. Filter chamber.
12. Pump suction chamber.
13. Overflow connections.
14. Overflow seal.
15. Drain valve.
19. Combination snifting valve for ventilating heating chamber and relieving excessive vacuum and pressure.
20. Open sink pan, controlling water regulating valve.
21. Vent pipe, to prevent accumulation of air at top of suction chamber.
22. Upper and lower retaining screens for filtering material.
23. Perforated copper heating trays.
24. Heating tray brackets.
25. Water inlet seal trough.

This illustration shows clearly the construction and operation of the vacuum feed-water heater, purifier and filter.

Materials used in its construction are cast iron for the shell, copper and brass for the valves and fixtures, each of which resist the destructive action of impure waters. The large heating chamber—upper section of the heater—is provided with perforated copper trays for the distribution of water, as hereafter explained. The entire valve gear, automatically controlling the water supply, is of brass.

As it will appear from illustrations, the shell is of cast iron, rectangular in form, and composed of two single piece main castings, securely bolted together.

The heater has an inclined bottom to facilitate thoroughness

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in draining, and is amply strengthened for the pressures obtaining in ordinary practice. Access to the interior may be had by removing the manhole doors located in both the heating and filtering compartments, the latter forming the heater base.

The water supply to the heater is controlled automatically, the valve for this purpose being operated by an open gravity sink attachment, by which the inlet of water to the heater is increased or diminished, as may be necessary to furnish the required amount of feed-water for the boilers, and also maintain a uniform water level within the heater.

The steam supply is drawn to the heater through a branch from the main exhaust pipe, with a valve in it. This obviates the necessity of expensive piping and further obviates the difficulty attending taking all of the exhaust steam with its entrained oil through the heater. *It also prevents the waste of water absorbed by the uncondensed steam passing through the heater.*

In the rectangular casting forming the steam connection to the heater there is placed an efficient *oil separator* of large surface, so constructed with steel baffles that the entrained water and oil are conducted to a receiving well at right angles to the flow of steam. The oil present in the exhaust is thus effectively separated and removed through a drain pipe of ample size provided for this purpose.

The feed water enters the heater through the water inlet at the top, and is discharged into and fills a trough, forming a water seal, thus preventing the familiar water hammer, which is caused by steam entering the water pipe when only partly filled. The water overflowing through the trough is then distributed over a series of oppositely inclined perforated copper heating trays, which in their vertical arrangement are staggered, so that the water in its downward course falls from tray to tray, and passing through the perforations is broken up in small particles, whereby it becomes thoroughly mingled with exhaust steam and absorbs all the heat possible. In leaving the trays the water falls upon a division plate on the heater which separates the heating chamber from the filtering chamber.

The filter is located in the large lower casing and operates in

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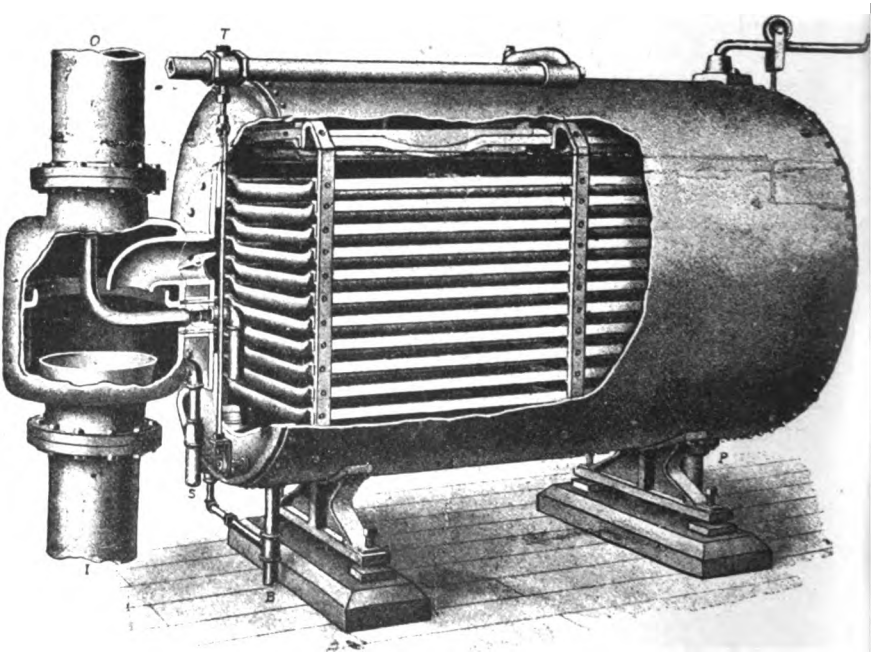
the following manner: After becoming heated to the highest attainable temperature, the water in the heating chamber passes through a down-cast pipe into the settling chamber, above which the filter bed is located. In this settling chamber opportunity is given for the precipitation and retention of the heavier solids and impurities without clogging the filter. On account of the large size of this chamber the water entering it remains in an almost quiescent state, insuring the rapid deposit of the heavier solids from the feed water.



HEATER NO. 3.

The water then rises upward through the cast iron perforated screens which hold the filtering material in place, through the filtering material and upper screens to the underside of the division plate, whence it travels to the pump outlet.

It will be manifest that the filtering material as arranged has

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only to deal with the lighter impurities in the feed-water, the heavier particles having been deposited in the settling chamber.

The filter bed is commonly composed of coke, excelsior, or other suitable material, which are contained between the perforated division screens.

The overflow for ordinary service in heating, purifying and filtering feed water, connection is made to the regular overflow outlet on the heater.

DESCRIPTION.

The cut on preceding page shows another type of vacuum heater.

By the use of this attachment great saving in the pipe work, valves and fittings for connecting the exhaust supply to the heater is affected. By this arrangement no valves are required for the exhaust pipe connections to the heater in order that the heater may be cleaned or examined while the plant is in operation.

As is clearly shown in the illustration, the exhaust enters the bottom of the chamber and passes out at the top direct to the atmosphere or to the heating system as may be desired. The exhaust steam flowing upward through the induction chamber strikes directly into the mouth of the large downwardly-curved pipe and supplies the heater with an ample amount of pure exhaust steam to heat the water to 210 degrees, even when the heater is worked to more than twice its rated capacity.

To allow the steam to enter the heater it is necessary that the air and gases be permitted to escape and this is accomplished by heating the small curved pipe where it passes through the chamber and also by the current of exhaust steam passing the upper end of the pipe.

The attachment is also a first-class oil eliminator and grease extractor. It is a well-known fact that oil and water follow the inner walls of the pipe and when steam enters the chamber this entrainment is first carried over the edges of the flaring nipple extending up into the body. This nipple and the inner walls form an annular well which is always partially filled with water, the surplus being drawn off by the drain pipe. Just above the centre and extending around the inner wall is another gutter which is

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also partially filled with water, the excess being drained off to the lower well by the small pipe shown at the side. The gutter is intended to catch any oil that may creep up the sides of the chamber and to insure its complete interception.

In the last two of the three heaters just described the vacuum principle is adhered to, and it has also had attention given to it in the first one, although the exhaust travels through it.

DESCRIPTION.

This heater consists of a cylindrical shell of steel plate, and is provided with neat cast-iron heads, the front one, B, of which is removable for taking out the pans and for access in cleaning. The exhaust steam enters at the back end, and, after passing through an ample self-cleaning oil catcher, A, it enters the heater proper, from which it escapes through the pipe, O, at the front end. The pipe, S, is the drip-pipe leading from the oil-catcher to the sewer.

The admission of water to the heater is automatically regulated by a drained float, shown underneath the oil-catcher, by operating the balanced valve at T. The float may be put in an upright 8-inch or 10-inch pipe attached to the suction if desired, in which case the balance valve will be at the other end of the heater. The water, on entering the heater, falls into the top pan first and flows downward over each pan to the chamber at the bottom of the shell, from which it passes to the pump through pipe P.

While in operation the pans are full of water and are completely surrounded by the exhaust steam in the shell. Owing to the convex shape of the bottom of the pans, the water is caused to flow in a thin film along the under side in such a manner that the exhaust steam always comes in direct contact with it, and thus heating it to the highest degree obtainable without back pressure. The pans afford ample settling chambers for the mud and solids in suspension to precipitate, and the lime and other solids in solution form, as fast as liberated, into scale on the under side of the pans.

It is claimed by the makers of the above last two heaters that

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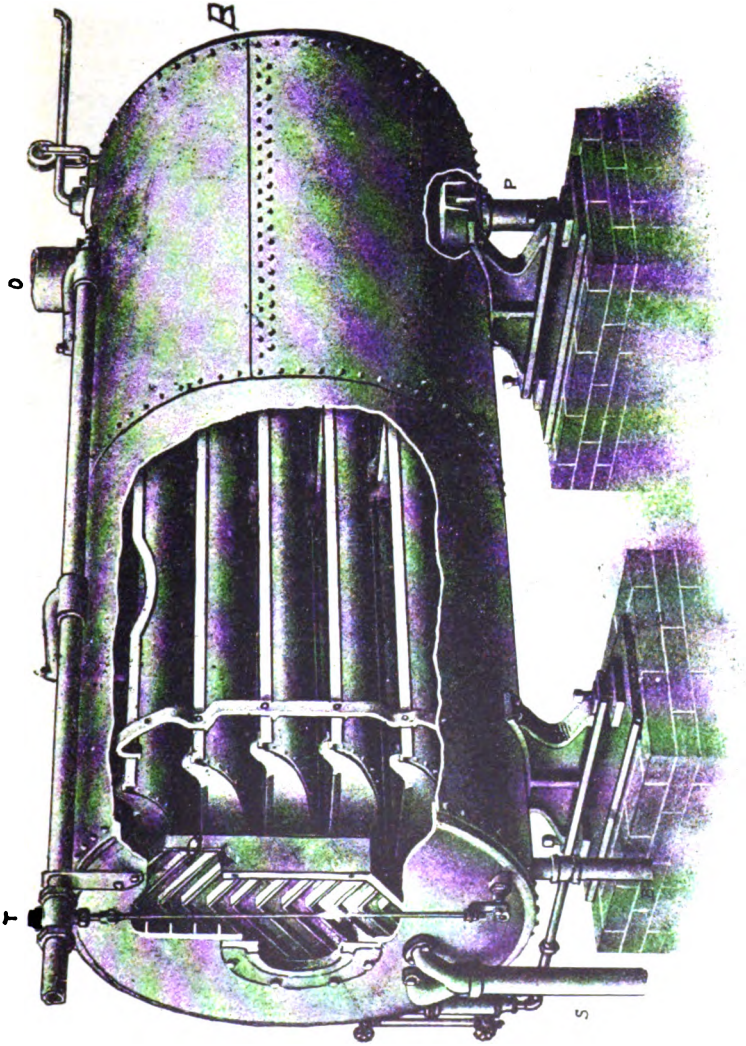

HEATER NO. 4.

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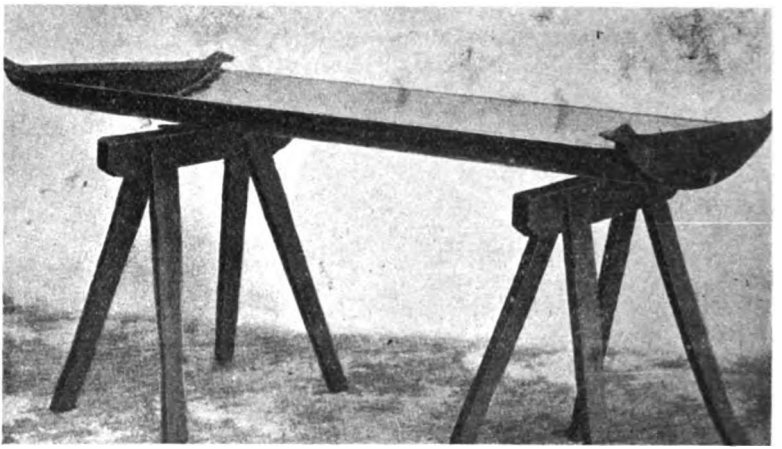
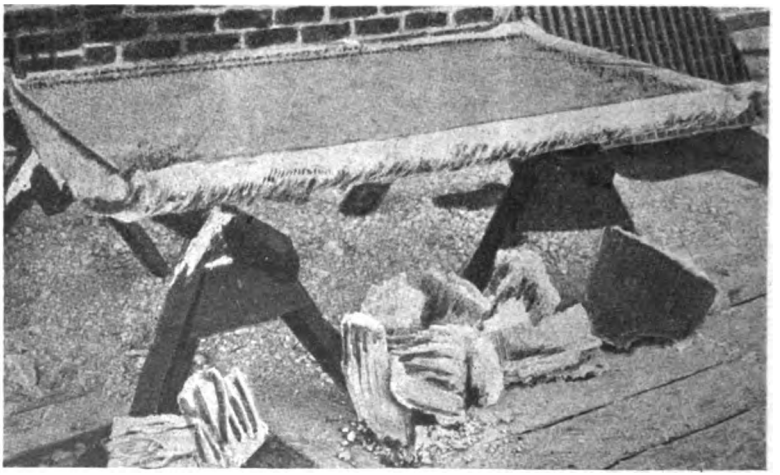


SECOND PAN FROM TOP (SAME AS SHOWN OPPOSITE) TAKEN FROM PURIFIER AT SPRINGFIELD, OHIO, WATER WORKS AFTER FORTY-TWO DAYS' RUN.



CLEAN PAN (30 INCHES WIDE BY 5 FEET LONG), TAKEN FROM A 350 H.P. PURIFIER AT SPRINGFIELD, OHIO, WATER WORKS BEFORE STARTING.

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no filtering arrangement is required because the pans thoroughly remove all the impurities that can be taken out or precipitated by exhaust steam. In support of this a cut of a pan before use is shown and another cut of the same pan after having been in use in the heater for forty-two days.

Our experience would indicate that a filtering arrangement would be of considerable advantage.

DESCRIPTION.

By referring to the drawing above it will be noticed that the exhaust steam is led into the heater through an inlet on the right, and impinges upon the concave baffle plate immediately in front. It then passes around the ends of the concave baffle and is thrown against the corrugations at the extreme ends of the separating chamber, and passes on into the body of the heater through two long, narrow ports on either side of the main baffle.

During its progress, it has been practically freed from cylinder oil, and it then commingles most thoroughly with the cold water, which enters at the point marked "Water Supply," and flows down slowly over the tier of inner and outer discharge pans as shown by the arrows. After passing completely over the entire set of pans, the water drops down into the pure water chamber, which comprises the entire area of the lower portion of the heater below the water line, except that taken up by the filtering and pure water chambers.

It will be noted that in proportion to the capacity of this heater, the settling space is very large, giving the water ample time to deposit in its passage, all the heavy particles, such as mud, sand, etc. It then passes upward through a filtering chamber, and overflows into the pure water chamber, from which point it is taken by the pump, as required.

It will be noted that the water level is automatically controlled by the float on the left, the cold water valve being attached on the pipe, just above the water supply inlet.

The method employed for draining the oil chamber of oil is also quite clearly shown.

It should be noticed that the overflow is entirely automatic

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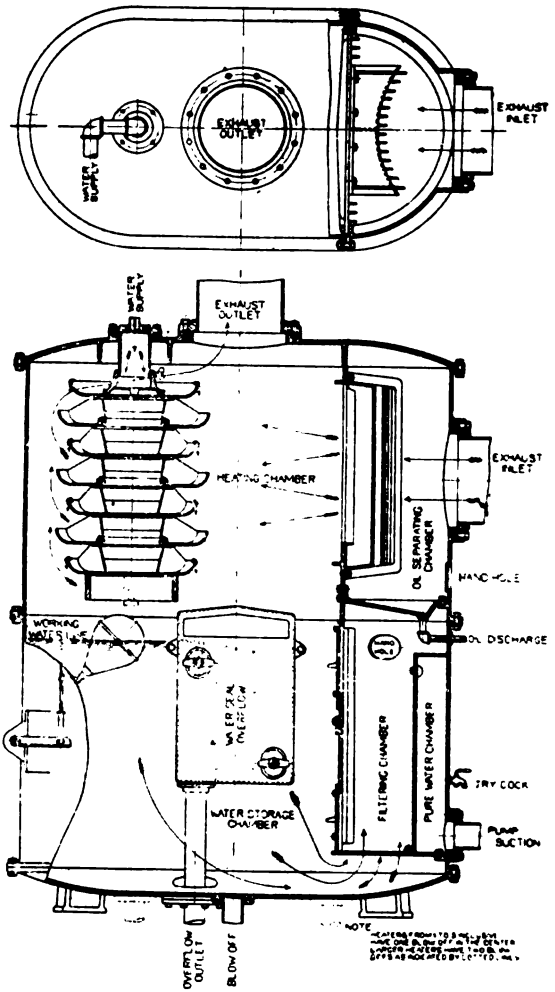

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in action, and provides for *skimming* off all floating particles and the small residum of oil which remains in the water after it has passed through the separator.

The heater is supplied with hand holes for cleaning out the oil chamber and also for washing out the filtering medium. Unless it is desired there is no possibility of back pressure on this heater on account of the fact that the outlet is made the same diameter as the inlet. The large hinged door provides almost instant access to any part of the heater.

The system of upward filteration should always be given much consideration as it not only makes it possible to use the same filtering material for a much longer time but prevents absolutely any floating particles from going into the boilers.

In connection with any heater there should be a by-pass so that the steam can be turned into heater or into the atmosphere at will. This will present itself in many accommodations and may be said to be absolutely necessary.

DESCRIPTION.

Cast iron, copper and brass are used for all parts exposed to steam and water because they do not quickly deteriorate from corrosion and acids.

The form of this heater is shown by the illustration. Each side is formed of one or more strongly ribbed parts bolted together at the flanges and made steam and water tight with rust joints calked from the inside. Suitable stay tubes and bolts are used in the large sizes, so that the shell being strong and rigid will not be affected by the pulsations of the exhaust steam. The top and bottom plates are also of cast iron, the latter being either dished or set at a slight angle to permit of complete drainage through the blow-off pipe.

The oil separator, through which the exhaust steam enters the heater, is bolted on the outside of the shell and is shown sufficiently clear in the accompanying cuts not to require any further explanation.

The upper portion of the heater contains the trays, which are interchangeable and removable. Each is inclined and the edges

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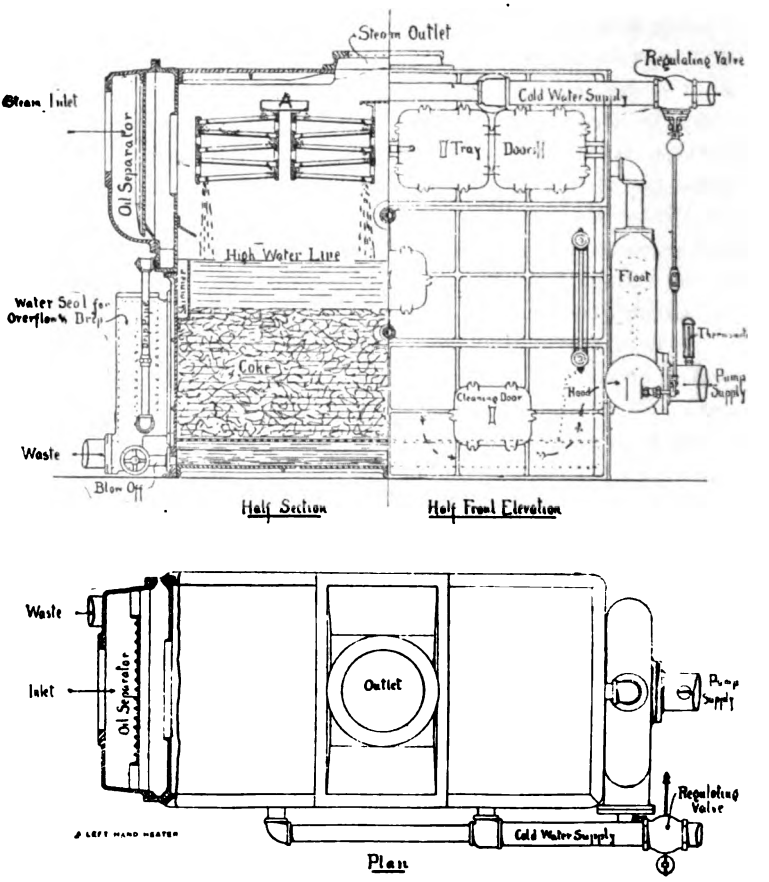

ILLUSTRATING HEATERS OF 2000 H. P. CAPACITY AND UPWARDS

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over which the water flows are serrated, or saw-toothed, for breaking up the water.

The trays are held in place by cast iron guides, securely bolted to the shell of the heater in such a manner that they cannot be dislodged by the pulsations of the exhaust, though they can be readily removed through the cleaning door openings.

Each set of trays is suspended in the steam space, with passages between the tray supports and the sides of the heater, giving far greater area for the passage of any surplus exhaust steam through the heater than the area of the exhaust inlet opening. This arrangement provides for delivering steam, *by induction,* through the openings in the tray guides to the water as it flows from tray to tray.

A brass pipe, with ell and nipple at end, form the opening in the heater through which the cold water enters, conducts the water to an open distributing box or trough extending across and above the trays. Slots are provided in the bottom of this box through which the water flows onto the upper tray.

Outside the heater on the inlet pipe is placed a double disc or balanced valve for regulating the cold water supply, which valve is controlled by a ventilated copper float carried in the heater. Any change in the level of the water raises or lowers this float, opening or closing, by crank and lever connections, the regulating valve, thus keeping supplied the demands that are being made upon the heater for hot water and preventing any waste of water through the overflow.

The ventilation of the float is accomplished by using a hollow brass stem connected to a hollow axis, the end of which projects without the heater. Any water that may accumulate in the float from sweating through the copper or from leakage will be shown on the stem outside the heater.

Just above the working level of the water is placed the *skimmer,* extending the width of the heater, which, in addition, furnishes the overflow opening. This trough is drained through an opening in the side of the heater into the water seal or trap, which seal, while of ample size and perfectly open, carries a sufficient head of water to withstand a pressure of about *one pound* per

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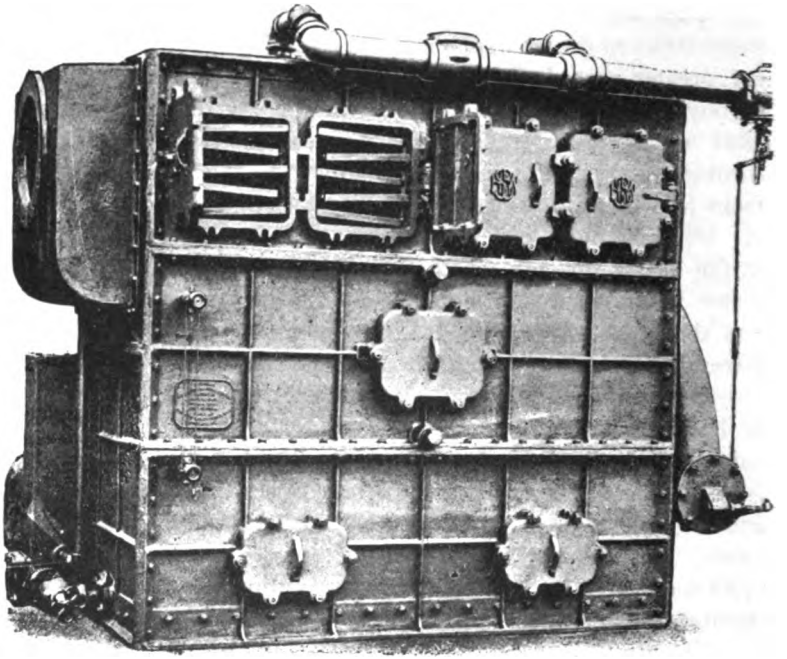
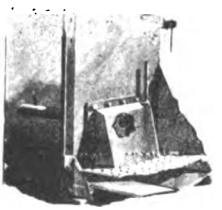
square inch. This arrangement effectually seals the opening and prevents the entrance of air into the heater when *drawing* the steam supply without using a check valve.

To provide for carrying additional depositing surface in the form of a filter bed, heaters should be furnished with perforated cast iron plates or shelving on which the material used is placed,



ELEVATION.



SHOWING VENTED HOOD PROTECTING PUMP SUCTION—PERFORATED CAST IRON PLATES FOR THE SUPPORT OF COKE OR OTHER FILTERING MATERIAL—SLOPING BOTTOM TO INSURE COMPLETE DRAINAGE WHEN BLOWING OUT.

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thereby ensuring the passage of all the water through the filtering bed, and providing an easy course to the pump suction via the hood. There plates form a false bottom, being set about 4 inches above the bottom of the heater.

Covering the outlet to the pump, and extending down to the coke shelving is a hood, open at its under edge for the passage of water, and vented by a pipe at the top to prevent possible air logging and consequent interference with the flow to the pump. This pipe also prevents a syphoning of the water from the heater, thus maintaining a seal for keeping the floating impurities from the pump suction.

It will, perhaps, have been noticed that some attention has been paid in the construction of all the heaters described, excepting the one shown in Fig. 4, to the induction of vacuum principle. This principle we regard as of the highest importance in exhaust steam heaters.

We think we have perhaps already devoted too much attention to the subject of the first part of the title of this paper, "Exhaust Steam Boiler Feed Water Heaters," and will now briefly take up the second part, "Hot Water Pumps and Pumping."

When water gets to 110°F. it is not safe to depend on any of the injector or inspirator types of feeding pumps, and the water must be delivered into the boiler by a force pump of positive action.

Pumping hot water is a very difficult problem, and its limitations of lift and temperature are very positive. As a general proposition it may fairly be said that, at sea level, a pump will not lift any water at 200°F. for boiler feed purposes, at sea level, the pump should be set at least 2 feet below the supply and the greater the distance the pump is set below the supply the greater will be the satisfaction in the pump's operations.

In designing pumps it is customary to allow a flow of 200 feet per minute in the suction pipe, 300 feet per minute in the discharge pipe and a piston speed of 100 feet per minute in water cylinder, making allowance in the cubic area of the cylinder for 25 per cent. of slip, but this rule when pumping hot water must be modified if good results are to be had. It is a safe rule to give

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the suction water a flow of 100 feet per minute and reduce the piston speed to 35 feet per minute. The writer has gone through a wide range of experience, and while he would not say that this rule should not be departed from he does affirm that it is the only rule that will guarantee a steady supply of hot water to the boiler if the plant is large and meet emergencies satisfactorily.

In connection with the suction there should be an open stand pipe, the open end being about 2 feet above the high water mark in the heater. This will allow some of the vapor to pass off in the passage from the heater to the pump, and also offers a ready cold water connection to the pump by enabling one to turn a stream of cold water from the tank into the stand pipe. The writer has also found it advisable to put a small pipe, say ½-inch, in the suction close to the pump, which can be used to reduce the pressure of the vapor which some times is so high that the pump does not get a full supply of water into the cylinder and immediately begins to jump or hammer. A very little water through the ½-inch pipe corrects this without a perceptible reduction in the temperature of the feed water.

There is also the difficulty of furnishing sufficient air chamber area to prevent hammer in the delivery pipe, which is very effectually overcome by the automatic air pump shown in cut below. This cut and description of its action is taken from "Pumping Machinery," by Wm. M. Barr.

"A piece of 2½-inch wrought iron pipe (*c*) about 30 inches long is connected to the end of the pump cylinder (*a*) in a vertical position, by means of a gate valve (*b*) or cock. A 2½-inch T (*d*) at the upper end of this pipe is connected at one end of the run with a 1¼-inch check valve (*e*) opening inwards, and at the other end with a ¾-inch check valve (*f*) that opens outwards. The valve (*f*) is connected with the air chamber through the pipe (*g*).

The air pump is operated as follows: When the pump is working, open the valve (*b*) to fill the pipe (*c*) with water; then partially close (*b*) until the check valves (*e*) and (*f*) begin to work. This is easily determined by the click of the check valves when seating. Its working may be described thus: When the

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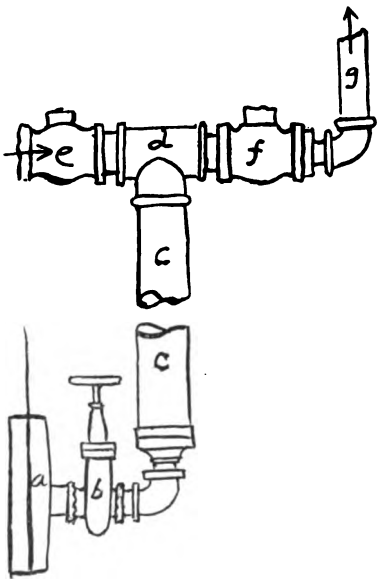
valve (*b*) is opened, water fills the pipe (*c*) from the pump cylinder (*a*) during the discharge stroke of the pump. By partly closing (*b*) when (*c*) is full, the pump during the suction stroke will draw a part of the water from (*c*) and air will flow in through (*e*) to take its place. During the next discharge stroke of the pump, more water is forced into (*c*), driving the air out through (*f*) and (*g*) into the air chamber. If (*b*) is opened too wide, all the water will be drawn out of (*c*) during the suction stroke and air



will be drawn into the pump cylinder from (*c*); but by properly regulating the opening, a column of water is kept in (*c*), which acts as a piston that moves with the strokes of the pump and pumps air into air chamber. Such an air pump will be sufficiently large to supply pumps with air that are delivering up to a million and a half gallons of water in 24 hours.

The writer, by the use of this automatic air pump, has got practically silent running in a pump that would have hammered itself and connection all loose in a short time without it.

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On the discharge line there should be placed a relief valve, so that when the water is shut off, or partly shut off, at the boilers the pressure will open the relief valve, which has a connection into the open stand pipe in suction before referred to, and allow the water to flow back into the pump suction. If there is not a man in attendance upon machinery close by, the pump may advantageously be equipped with a speed governor.

Having settled all the foregoing points it is now a matter of making a proper selection of pump and valves.

The writer, after 25 years' intimate experience with high pressure pumping, has become very partial to double acting outside packed plunger pumps, with both suction and discharge valve put in the top of the pump, pot fashion, and held in position by glands. In such a pump individual valves can be examined without taking any other piece of the pump apart. The plungers being outside and outside packed and the valves outside there is never any cause for doubt as to what part of the water end is out of order when the pump will not do its duty. The writer uses the outside packed plunger pump to the exclusion of all others, but for low resistance in discharge line he uses the common style of plunger water end and valves, but for high duty, 100 pounds or over, he always uses the pot-shaped valve.

Such a pump is more costly when purchased, but is much cheaper in the end. There is a pump of this kind which has been under the writer's charge for nearly eight years, and up to date it has only cost $50.00 for repair, and has not failed for a single hour in all that time to meet every requirement. It pumps regularly against a head equal to 150 lbs. per square inch.

Such pumps may be either single or duplex. The duplex has the advantage of steadier flow, but the stroke of the one piston is dependent for its steam on the stroke of the other piston, and on this account presents some difficulties that may out-balance the steadier flow.

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